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PHYSICS ABSTRACTS

SECTION A

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SCIENCE ABSTRACTS

SECTION A, PHYSICS

SECTION B, ELECTRICAL ENGINEERING

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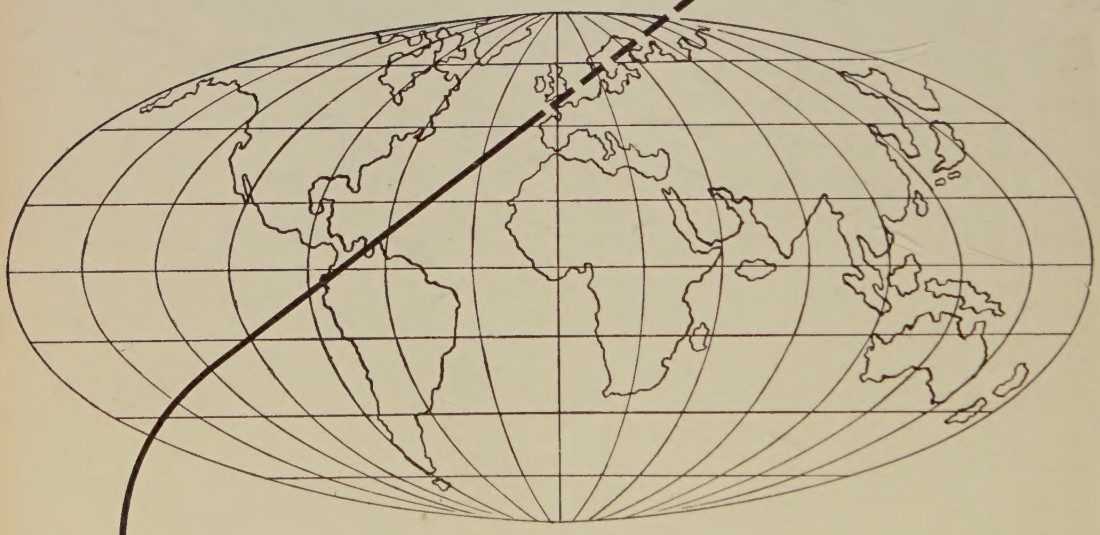

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Electroacoustic apparatus
Radiocommunication
Mechanical engineering
Illumination

LIST OF JOURNALS

The following list supplements the List of Journals published with the January number of Volume 56 (1953) and the Supplements published with the Indexes to Volumes 56 (1953) and 57 (1954). Reprints of the List of Journals (1953) and the Supplements (1953 and 1954) can be obtained from The Institution of Electrical Engineers, Savoy Place, London, W.C.2, price 2s. 0d. post free.

The addresses given are believed to be correct at the date of publication, but no responsibility can be accepted for errors.

Atomic Energy Canada Rep.	*Atomic Energy of Canada Ltd. Reports.* Scientific Document Distribution Office, Atomic Energy of Canada Ltd., Chalk River, Ontario, Canada.
J. Instn Loco. Engrs	*Journal of the Institution of Locomotive Engineers.* 28 Victoria Street, London, S.W.1.
Trans Elect. Supply Authority Engrs Inst. New Zealand	*Transactions of the Twenty-Fifth Annual Conference of the Electric Supply Authority Engineers' Institute of New Zealand (Inc.)* G.P.O. Box 1001, Wellington, New Zealand.
Uspekhi Fiz. Nauk	*Uspekhi Fizicheskikh Nauk.* Mezhdunarodnaja Kniga, Moscow.

Note

For all periodicals published by The Pergamon Press, the address is now as follows: Pergamon Press, 4 and 5 Fitzroy Square, London, W.1.

Errata

Abstr. 2707 (1955) line 7: *for* 1 *read* 0.

Abstr. 3244 (1955) line 3: *for* 75–120 *read* 6–42.

Abstr. 3245 (1955) line 3: *for* 38–74 *read* 3–48.

Abstr. 3853 (1955) line 5: *for* waves *read* curves.

Corrections to Articles

Corrections have been published, as shown below, to the articles whose abstract numbers are given. Unless otherwise stated, the volume and page given refer to the journal named in the abstract, i.e. the journal in which the original article was published.

Abstr. 6169 (1953): **27,** *No.* 1, 76 (*Jan.*, 1955).

Abstr. 9431 (1954): **4,** 292 (*April*, 1955).

Abstr. 244 (1955): **23,** *No.* 4, 763 (*April*, 1955).

Abstr. 2936 (1955): **23,** *No.* 4, 762 (*April*, 1955).

Abstr. 3239 (1955): **23,** *No.* 4, 762 (*April*, 1955).

MATHEMATICS 51

513.811 : 530.145

4280. An attempt to work out a finite system corresponding to a special case of Schrödinger's non-relativistic model of the linear harmonic oscillator. G. JÄRNEFELT. *Comptes rendus du Douzième Congres des Mathématiciens Scandinaves. Lund*, 10–15, *Aug.*, 1953, *pp.* 116–34.

Various finite approximations to the Euclidean plane are considered and tentative suggestions are made concerning corresponding approximations to the oscillator wave equation. See also Abstr. 4550, 4582 (1953). R. A. NEWING

517.512 : 518.5

4281. Frequency analysis of computer systems. R. BOXER. Letter in *Proc. Inst. Radio Engrs*, **43**, *No.* 2, 229 (*Feb.*, 1955).

Shows that the z-transform ($z = \exp ST$ where S is the complex frequency and T the sampling interval) may be derived directly in closed form by means of the "jump function" of Gardner and Barnes [*Transients in linear systems*, New York: John Wiley and Sons (1942), pp. 286–7]. T. J. REY

517.86

4282. Loci of some elementary transcendental functions. H. WAHL *Frequenz*, **8**, *No.* 12, 372–8 (*Dec.*, 1954) In German.

The cos, sinh and cosh of a complex variable are analysed graphically as in the previous article [Abstr. 2354 (1955)] with examples of the construction of loci for particular cases. The simple operations needed to convert a circular into a hyperbolic function are specially featured. S. C. DUNN

518.2

4283. Tables of the Racah coefficients $W(\bar{a}\bar{b}\bar{c}\bar{d}; \bar{e}\bar{f})$. II. Coefficients having three half-integral variables $\bar{a}$, $\bar{c}$ and $\bar{e}$ ($f = 0, 1, 2, 3$ 4). S.-Y. OBI, T. ISHIDZU, H. HORIE, S. YANAGAWA, T. TANABE AND M. SATO. *Ann. Tokyo Astron. Obs. Univ. Tokyo* (*Second Ser.*) **4**, *No.* 1, 3–74 (1954).

For Pt I, see Abstr. 3017 (1954). Contains 29 numerical tables and an introduction.

ASTRONOMY . ASTROPHYSICS . GEODESY 52

523.161

4284. On the stability of the binary system in the fluctuating density field of the interstellar matter. B. TAKASE. *Ann. Tokyo Astron. Obs. Univ. Tokyo* (*Second Ser.*) **3**, *No.* 4, 192–5 (1953).

Considers gravitational interaction. Using the "continuous picture" for the distribution of the interstellar matter recently proposed by Chandrasekhar and Münch, the spatial correlation of the gravitational forces acting at two points in the region is considered. After these analyses the time of dissolution of the binary is found in a form of equation. A.

523.161

4285. Interstellar hydrogen and the local system. D. S. HEESCHEN AND A. E. LILLEY. *Proc. Nat. Acad. Sci. U.S.A.*, **40**, No. 12, 1095–6 (*Dec.*, 1954).

Systematic observations of the 21 cm H line for the sections of the galactic centre and anti-centre reveal two distinct features of brightness distribution. The brightness-temperature reaches a peak value in the galactic plane and drops off rapidly with latitude as expected; but, in addition, a second concentration of H occurs along a line inclined at 20° to the plane, corresponding closely to "Gould's Belt" of bright, early-type stars. Thus the nearby clouds of neutral H appear concentrated in this same belt, pointing to the existence of a local system which contains an appreciable fraction of all the matter in the immediate neighbourhood of the sun. D. R. BARBER

523.161

4286. On the abundance of interstellar beryllium. L. SPITZER, JR AND G. B. FIELD. *Astrophys. J.*, **121**, *No.* 2, 300–5 (*March*, 1955).

A search for the ultraviolet Be II lines on high-dispersion spectra of χ^2 Ori and ζ Per yields negative results. The resultant upper limits on N (Be II), the number of Be II ions in the line of sight, combined with the values of N (Na I), found from the ultraviolet Na doublet, yield an upper limit of about 2×10^{-3} for N (Be II)/N (Na I). To find the overall Be/Na ratio, this upper limit must be decreased by the ratio N (Na I)/N (Na II), whose value will depend on whether the absorbing cloud is an H I or an H II region. The assumption that the ratio of gas to dust is the same in these clouds as in the Galaxy at large makes it possible to compute the number of H atoms in the line of sight from the observed colour excess. This computed number is an order of magnitude too great for an H II region, in view of the absence of any interstellar Balmer emission from the neighbourhood of these stars. Analysis of conditions in an H I region shows that N (Na I)/N (Na II) is probably about 2×10^{-2}, and the ratio N (Be)/N (Na) becomes less than about 4×10^{-5}. This low value is about an order of magnitude less than the mean of the values found in the sun or in meteorites. The ratio N (Ca)/N (Na) is also believed to be less in the interstellar gas than in the sun and in meteorites by a factor of about 40. Possibly both Ca and Be atoms, to a greater extent than Na atoms, may be locked up in grains. A.

523.164

4287. Radio astronomy in Hawaii. G. REBER. Letter in *Nature* [*London*] **175**, 78–9 (*Jan.* 8, 1955).

Observations have been made from an altitude of 10 020 ft by the Lloyd's Mirror technique on frequencies near 20, 30, 50 and 100 Mc/s; on only the highest frequency are observations sufficiently free from ionospheric anomalies for an intelligible inter-

pretation. The variation of clarity of the interference and diffraction patterns of the solar radiation with change of azimuth of sunrise are reported, and interpreted in terms of a turbulent scattering extension of the earth's upper atmosphere whose shape approximates to that of a thick disk some 30° to 40° wide. Asymmetries of the Cassiopeia and Cygnus sources are also reported. M. W. OVENDEN

523.164

4288. Observations of galactic radiation on a wavelength of 33 cm. J.-F. DENISSE, E. LEROUX AND J.-L. STEINBERG. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 3, 278–80 (*Jan.* 17, 1955) In French.

The emission in the neighbourhood of the galactic equator on 33 cm (due primarily to ionized hydrogen) has been observed in the declination range −30° to +50°. An isophotal map is given in units of temperature ~3°K. Fourteen localized sources are observed; one is the galactic nucleus, and others are known from observations on other wavelengths, but five new sources are reported, one possibly associated with the North American nebula. M. W. OVENDEN

523.164

4289. A detailed radio map of the sky. J. D. KRAUS AND H. C. KO. *Nature* [*London*] **175,** 159–61 (*Jan.* 22, 1955).

Observations were made on 250 Mc/s with an aerial whose sensitivity pattern is 1° wide between half-power points in right ascension and 8° in declination. Radio isophotes for units of 10^{-25} W.m^{-2}.(c/s)$^{-1}$. deg^{-2} are plotted on Mercator's projection for the ranges 12^h–24^h in right ascension, and −40°–+65° in declination, equinox 1950.0. The map shows the well-known localized sources such as Cass A and Cygn A, as well as a number of extended sources, one of which coincides with the plane of the supergalaxy. The highest elevation, designated Sagittarius A, has co-ordinates R.A. $17^h\,42^m\,48^s \pm 15^s$, Dec. $-28°\,50' \pm 30'$, and is identified as the galactic nucleus. Longitudinal and transverse profiles across the galactic nucleus are given, and the evidence for radiation from spiral arms discussed. M. W. OVENDEN

523.53

4290. Observations of distant meteor-trail echoes followed by ground scatter. W. L. HARTSFIELD. *J. geophys. Res.*, **60,** *No.* 1, 53–6 (*March*, 1955).

Observations of backscatter on 13·7 Mc/s over a south-easterly path from Sterling, Virginia, revealed the existence of meteor-trail reflections just ahead of the main body of the backscatter, demonstrating that the latter was from the ground in these instances. The existence of apparent two-hop backscatter without the appearance of one-hop was noted in a number of cases. Possible reasons for this behaviour are discussed. A.

523.72

4291. A study of solar radio radiation on 9 350 Mc/s, near sunset and sunrise. I. KAZES AND J.-L. STEINBERG. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 5, 493–5 (*Jan.* 31, 1955) In French.

Daily observations of the sun near rising and setting have been made with an equatorially-mounted paraboloid of 1·5 m aperture and angular sensitivity 85′ between half-power points. The equatorial component of refraction and the total refraction on 3·2 cm are compared with the mean optical refraction. Absorption becomes pronounced for altitudes less than 20°. Quasi-periodic variations of intensity, increasing with decreasing altitude and strongly dependent upon meteorological conditions, are reported, and it is shown that these fluctuations cannot be due to a variation of the direction of the source.

M. W. OVENDEN

523.72

4292. Interferometric observations of solar radiation on 9 350 Mc/s. I. ALON, J. ARSAC AND J.-L. STEINBERG. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 6, 595–8 (*Feb.* 7, 1955) In French.

Interferometric measurements have been made of the distribution of radio brightness across the solar disk on 9 350 Mc/s. The apparent diameter of the sun is slightly greater than the optical apparent diameter, and the existence of limb-brightening is confirmed.

M. W. OVENDEN

523.72

4293. Non-linear plasma oscillations and bursts of solar radio emission. S. F. SMERD. Letter in *Nature* [*London*] **175,** 297 (*Feb.* 12, 1955).

The observed characteristics of bursts of solar radio emission, especially the frequency drifts and the pronounced second harmonics, suggest non-linear plasma oscillations as the origin of the radiation. It is shown that exact travelling-wave solutions, rich in even harmonics, can be obtained for non-linear plasma oscillations, the case investigated being that of longitudinal electron oscillations in a plasma stream. Effects of temperature and magnetic fields are neglected.

M. W. OVENDEN

523.72 : 523.745

4294. On the correlation between radio-frequency radiation from the sun and solar activity. E. TANDBERG-HANSSEN. *Astrophys. J.*, **121,** *No.* 2, 367–75 (*March*, 1955).

An investigation is made of the correlation between radio-frequency radiation from the sun and solar activity, sunspots, prominences, and geomagnetic disturbances. The difference in observed directivity and intensity of the radiation at different frequencies is explained by the reflection conditions in the sun's atmosphere. A distinction is made between radio-noise active and radio-noise inactive sunspots. A.

523.72 : 538.561

4295. Effect of magnetic fields on generation of noise by isotropic turbulence. R. M. KULSRUD. *Astrophys. J.*, **121,** *No.* 2, 461–80 (*March*, 1955).

Lighthill's (1952) and Proudman's (1952) results on the generation of aerodynamic noise by isotropic turbulence are generalized to include magnetic effects. It is found that if there are only turbulent magnetic fields present and no constant magnetic field, the magnetic turbulence generates sound very efficiently and increases considerably the generation of sound by kinetic turbulence. If there is a constant magnetic field, hydromagnetic waves are generated instead. For the modified sound mode of the hydromagnetic waves, a result similar to the case of no general field is obtained. No energy is generated into the Alfvén and modified Alfvén waves unless the energy density of the magnetic field is greater than the energy density

of the kinetic turbulence. Expressions are found for the rate of noise generated per unit mass, and these results are applied to the problem of heating the chromosphere and the corona. A.

523.743

4296. On the solar granulation. G. THIESSEN. *Z. Astrophys.*, **35**, *No.* 4, 237–44 (1955) In German.

The discussion of new observations with the Hamburg–Bergedorf telescope, aperture 60 cm, seems to establish the actual existence of the "classical" 1″–2″ granulation. The granules are of polygonal shapes. They are, on the average, 35% brighter than the background at λ 5650 Å. The turbulent velocities of the observable granulation are discussed, in particular those found by Richardson and Schwarzschild in 1950; they are found to be $\pm 1 \cdot 85$ km/sec, after an appropriate correction for scattered light has been applied. The granulation produces a strong limb-effect in wavelength, namely a violet shift, which decreases from 0·34 km/sec at the centre of the solar disk to zero at the limb. A. BEER

523.743

4297. On bright-dark symmetry of solar granulation. A. SKUMANICH. *Astrophys. J.*, **121**, *No.* 2, 404–7 (*March*, 1955).

The possible existence of a statistical asymmetry between bright and dark in granulation intensities is investigated. Direct photographs of the quiet sun, taken with the 60 ft tower telescope of the Mount Wilson Observatory, were used. Two isophotes were determined, so that the total bright region (i.e. brighter than the isophote) formed 20 and 80% of the total area of the field, respectively. The frequency distribution according to size of singly connected regions for both isophotes (bright on the 20% and dark on the 80% isophote) were obtained and intercompared. Only a very slight excess of bright regions was found, which implies a slight—if any—bright asymmetry. Further, a similar test based on the frequency distribution of granulation intensities did not show any appreciable asymmetry. Thus a strong bright-dark asymmetry, as implied by the traditional rice-grain picture of solar granulation, does not appear to exist, at least not for the granulation elements resolved on the Mount Wilson plates. A.

523.746

4298. The formation of sunspots from the solar toroidal field. E. N. PARKER. *Astrophys. J.*, **121**, *No.* 2, 491–507 (*March*, 1955).

It is shown that a horizontal magnetic flux tube in an electrically conducting atmosphere is buoyant and will tend to rise. This magnetic buoyancy is large enough to bring an occasional strand of flux from the general solar toroidal field up into the photosphere, if general field densities of a few hundred gauss. farther down are assumed. Identifying the intersection of such ropes with the photosphere as the source of sunspots, several general characteristics of the spots may be deduced, e.g. east–west orientation, bipolarity, appearance only in low latitudes, migration, reversal of polarity, etc. The linearized static equilibrium equations for a flux tube are developed. With a cooling mechanism, such as that suggested by Biermann (1941) it is found from the equilibrium equations that a sunspot group should consist of a diffuse flux tube of 10–100 gauss and 10^5 km extent in the photosphere, forming eventually a number of cool intense cores of several thousand gauss. A.

523.75

4299. The sun's magnetic field, 1952–1954. H. W. BABCOCK AND H. D. BABCOCK. *Astrophys. J.*, **121**, *No.* 2, 349–66 (*March*, 1955).

More than 450 magnetograms, showing the distribution, intensity, and polarity of weak magnetic-fields ($>0 \cdot 3$ gauss) on the sun have been obtained with the solar magnetograph over a two-year period. This interval includes the recent minimum of solar magnetic activity. The records show a pattern with a fluctuating fine structure and certain large-scale regularities. Consistent evidence is found for a general magnetic field, predominantly dipolar, with polarity opposite to that of the earth. The mean intensity is of the order of 1 gauss. The general field is usually limited to heliographic latitudes greater than about $\pm 55°$; it has a varying fine structure and shows remarkable random fluctuations in effective intensity and extent. There seems to be no prevailing obliquity between the magnetic and rotational axes. The total flux is estimated to be nearly 10^{22} maxwells. In the lower latitudes the stronger magnetic effects appear as contiguous areas of opposite magnetic polarity, as if loops of a submerged toroidal field were occasionally brought to the surface by rising material. These bipolar magnetic (BM) regions obey Hale's laws of sunspot polarity, but spots are comparatively rare, occurring, when at all, within the BM regions while they are young. Ca II *plages* are observed where the field intensity is greater than about 2 gauss. Hydrogen filaments occur around the borders of BM regions or, alternatively, seem to divide the region into parts of opposite polarity. As the regions age, they generally expand, showing a decrease in field intensity, and disintegrate until lost in the background of irregular weak fields. There is much diversity in total magnetic flux, duration, area, and course of development. Occasional extended magnetic areas of only one outstanding polarity were recognized. The most prominent unipolar magnetic (UM) region of 1953 had an intensity $\lesssim 3$ gauss and a duration of many months; it may well have been related to a prominent sequence of 27-day-recurrent terrestrial magnetic storms. UM regions may be remnants of disintegrating BM regions. It is suggested that UM regions may be identified as the heretofore hypothetical "M" regions of Bartels. Repeated tracings of the same area of the sun at intervals of a few minutes show changes of the order of 1 gauss. in the fine structure of the magnetic pattern within a half-hour. The observations provide objective evidence for the heretofore inferential hypothesis that magnetic fields are fundamental to sunspots, *plages*, prominences, chromospheric fine structure, bright coronal emissions, and, probably, regions of strong radio emission. Several solar phenomena can be synthesized on the proposition that neutral but ionized corpuscular streams are continually being ejected from all turbulent regions of the surface characterized by coherent magnetic fields of average intensity $\frac{1}{2}$ gauss or more. A hydromagnetic model, based on chromospheric spicules, is proposed for such ejection. A.

523.75

4300. Heights of solar flares. J. W. WARWICK. *Astrophys. J.*, **121,** *No.* 2, 376–84 (*March*, 1955).

The observed area of a solar flare is a combination of two areas: the area of the sides of the flare as it would be seen at the limb and the area of the top of the flare as it would be seen at the centre of the disk. The change in measured areas of Hα flares observed at the centre of the disk and at some distance from the centre of the disk is used to derive information on heights of flares. A preliminary analysis of the raw data indicates that flares are neither flat nor needle-shaped. Explicit height distributions, functions of flare area, are derived from the smoothed data. The shape assumed here for a typical flare appears to be more realistic than that proposed by Waldmeier. The height-frequency distribution is well represented by $\exp[-\beta h]$, where β is the reciprocal of 20 300 km. Flares at the limb of the sun should therefore be visible as low, but extremely bright, prominences. A.

523.75

4301. Flare height and association with SID's. C. S. WARWICK. *Astrophys. J.*, **121,** *No.* 2, 385–90 (*March*, 1955).

The measured heights of limb flares yield a height-frequency distribution that agrees, within observational uncertainties, with that derived by J. W. Warwick from areas of disk flares. No certain case is found of an SID (sudden ionospheric disturbance) associated with a flare of height less than 15 000 km above the Hα limb. The existence of a minimum flare height for SID association suggests that SID's are caused by Lyman radiation rather than by soft X-rays. The observed value of 15 000 km for the minimum height above the Hα limb agrees fairly well with the value 11 000 km, the height above the photosphere at which optical depth becomes unity for Lyman-α radiation in Piddington's model. Values of the fraction of SID-associated flares at different distances from the centre of the disk are consistent with the idea of a critical flare height for SID association. A.

523.75

4302. Investigation of turbulence in the solar atmosphere. M. S. UBEROI. *Astrophys., J.*, **121,** *No.* 2, 400–3 (*March*, 1955).

The correlation and the spectrum of solar granules are measured by a simple technique, and the results are compared with data obtained by orthodox methods. Published data are analysed to give a direct evidence of convective heat transfer in the solar atmosphere. A.

523.75

4303. On thermal convection in a polytropic atmosphere. A. SKUMANICH. *Astrophys. J.*, **121,** *No.* 2, 408–17 (*March*, 1955).

Thermally induced convection is investigated in an atmosphere with a strong density variation from top to bottom, such as is found in the hydrogen convection zone of the sun. The atmosphere is assumed to be initially stratified in horizontal planes and to follow the polytrope law, $P \propto \rho^{\Gamma}$. Viscosity and heat conduction are ignored, the perturbations are assumed to be adiabatic, and the perturbation equations are linearized. It is found that in a polytropic atmosphere —in contrast to the classical case of a homogeneous atmosphere—the speed of development of a perturbation increases persistently with decreasing horizontal wavelength of the perturbations, even for wavelengths shorter than the thickness of the atmosphere. Thus in the solar hydrogen convection zone small element sizes are to be expected to predominate. A.

523.75 : 532.5

4304. Magnetohydrodynamic waves under the action of the Coriolis force. II. B. LEHNERT. *Astrophys. J.*, **121,** *No.* 2, 481–90 (*March*, 1955).

For previous part, see Abstr. 8868 (1954). The phase velocity of a single plane magnetohydrodynamic wave in a rotating liquid is independent of the amplitude. The non-linear interactions between the components of the spectrum of a complex travelling disturbance vanish only in a non-rotating fluid without dissipation. A criterion for the approximate validity of the principle of superposition is given for small values of the Coriolis force and the dissipation. In a rotating medium in a magnetic field a disturbance will not necessarily travel along the magnetic field lines. The anisotropic group velocity for a wave packet is given. In solar physics the effects of anisotropic dispersion and non-linearity are significant for disturbances with wavelengths of the order of a hundredth of the solar radius, if a dipole field with a polar strength of less than 25 gauss is assumed. A.

523.752

4305. On the rapid changes in the fine structure of the chromosphere near a centre of solar activity. S. L. LIPPINCOTT. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 6, 593–5 (*Feb.* 7, 1955) In French.

The elements of the chromospheric fine-structure have been measured on a cinematographic sequence, obtained at the Observatoire du Pic du Midi by B. Lyot in 1942. Movements, dimensions and lifetime have been studied on a selection of 65 exposures.

A. BEER

523.755

4306. The regions of coronal emissions and their relation to sunspots and faculae. A. BRUZEK. *Z. Astrophys.*, **35,** *No.* 4, 213–32 (1955) In German.

The basic material of this investigation are all available coronagraphic data, obtained at all active solar observatories during the period 1943–53. A study is made of lifetime, evolution and position relative to the spots and faculae, and also of the relation between the latter ones and the intensity and intensity distribution of the green coronal line at λ 5 303 Å. It is shown that the faculae of isolated spot-groups and the corresponding regions of coronal emissions develop simultaneously, and are of about the same duration. Only for small groups, however, number of spots and coronal intensity are clearly correlated; above the very large spots the intensity is often smaller than above the less-extended spots, and sometimes even an intensity minimum is observed. Faculae seem thus to cause an intensification, large spots a weakening of the green line; the latter effect is much less pronounced for the red coronal line at λ 6 374 Å.

A. BEER

523.755

4307. Study of the variation of absolute brightness in the corona with the solar cycle. W. Abbott. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 7, 729–31 (*Feb.* 14, 1955) In French.

From published photometric observations of the solar corona during the total eclipses of 1914, 1929, 1937, 1941 and 1945, curves are given of radial distance from the solar limb against phase of the solar cycle for seven intensity levels between $0{\cdot}25\times10^{-6}$ and $0{\cdot}14\times10^{-8}$ of the mean brightness of the solar disk. The zone of maximum variation of brightness lies between 1·0 and 2·0 solar radii from the limb, and the variation throughout the cycle disappears for distances from the limb greater than about 3·8 solar radii. In the zone of maximum variation, the ratio of the brightness at maximum of the cycle to the brightness at minimum is about 2·2. M. W. Ovenden

523.76

4308. A model for the internal structure of the sun. G. O. Abell. *Astrophys. J.*, **121,** *No.* 2, 430–8 (*March*, 1955).

A model for the structure of the sun is given, in which the proton–proton nuclear process is assumed to be the source of all the sun's energy. Homogeneity of chemical composition and an envelope in radiative equilibrium are assumed, and interpolation formulae for opacity are adopted. The calculations show that a model based on these assumptions and interpolation formulae does not permit possible chemical abundances of the elements. It is suggested that this difficulty arises from the neglect of the consumption of hydrogen in the centre of the sun and the possibility of an outer convection zone. A.

523.77

4309. On the excitation of neutral oxygen in the solar chromosphere. O. Namba. *Publ. Astron. Soc. Japan*, **6,** *No.* 2, 87–102 (1954).

The high excitation of neutral oxygen observed in the flash spectrum is attributed to resonance fluorescence with the hydrogen radiation field in the chromosphere. Owing to the coincidence of ionization potentials for these two elements, strong Lyman continuous radiation would ionize oxygen atoms highly and over-populate the excited levels through the subsequent recombination process, giving ionization and excitation temperatures comparable with those for hydrogen. The resonance excitation of oxygen with Lyman-β line emission is also considered. A brief estimation shows that, in the chromosphere, this effect may be less important than that of the Lyman continuum. A.

523.77

4310. On the calculation of non-coherent contours. S. Miyamoto. *Publ. Astron. Soc. Japan*, **6,** *No.* 2, 103–8 (1954).

The accuracy of the theoretical non-coherent contour calculated by the approximate replacement of the frequency mean $\bar{J}(\tau)$ of the mean intensity $J(\xi, \tau)$ by the mean intensity $J(0, \tau)$ at the line centre, has been estimated in deriving the second approximation formula. Numerical calculation shows that for solar H and K lines, the first approximation gives sufficiently accurate results for the purpose of comparison with observations. A.

523.774

4311. The curve of growth and the excitation temperature for the Fraunhofer lines of the solar atmosphere. H. Inaba. *Sci. Rep. Tôhoku Univ. First Ser.*, **38,** *No.* 1, 31–49 (1954) In French.

Empirical *f*-values for Ti II and Fe I are derived, from Wright's curve of growth, using measurements of equivalent widths. Their pronounced variation with wavelength is outlined. The subsequent redetermination of the excitation temperatures of these two atoms leads to values somewhat higher than those of Wright. Using Minnaert's theory of absorption, relations between the number of absorbing atoms and wavelength are obtained on the basis of the temperature distribution derived from measurements of the darkening effect in the continuous spectrum. It is concluded that the systematic errors of the *f*-values are essentially caused by the physical conditions governing the formation of the lines in the solar atmosphere. In conclusion, the excitation temperatures of metallic atoms are briefly discussed, with a view to constructing their curves of growth. A. Beer

523.774

4312. Infrared solar spectrum. L. Goldberg. *Amer. J. Phys.*, **23,** *No.* 4, 203–22 (*April*, 1955).

An account is given of recent results obtained from the study of the infrared solar spectrum with modern grating spectrometers and detectors. The discussion is divided into three parts, namely, the sun's continuous spectrum, the solar absorption-line spectrum, and the telluric- or terrestrial-line spectrum. A.

523.775

4313. CN bands in the chromosphere. J.-C. Pecker and R. G. Athay. *Astrophys. J.*, **121,** *No.* 2, 391–9 (*March*, 1955).

CN bands are observed in emission in the chromosphere between the photospheric limb and a height of 750 km. Spectrograms obtained by the High Altitude Observatory at the Khartoum eclipse in 1952 showed a scale height of 210 km for the intensity of the emission in the $^2\Sigma \rightarrow {}^2\Sigma(0, 0)$ band at λ3883. The emission spectrum at 100 km gives a rotation temperature of ~4 500°, and the photospheric absorption spectrum in the Utrecht *Atlas* gives a rotation temperature of ~4 000°. At eclipse heights other than 100 km, the data were used to determine the temperature gradient. The rotation temperature was found to increase with height. Photospheric and chromospheric models were used to predict the absolute intensity of the CN emission in this band. The predicted intensity was less than the observed intensity by a factor of 20. The discrepancy was accounted for by uncertainties in the absorption coefficient, which was obtained from a study of the absorption profile in the Utrecht *Atlas*. A.

523.775

4314. Spin-orbit parameters for the p^2 configuration, with special reference to the yellow coronal line. H. Zirin. *Astrophys. J.*, **121,** *No.* 2, 528–32 (*March*, 1955).

Parameters of variational wave-functions for the $1s^22s^22p^2$ configuration with $Z = 6$–15 and 20 are given. These are used to calculate the spin-orbit parameter ζ, as well as the spin-spin parameter η, for this isoelectronic sequence. The theoretical values so

obtained are found to agree closely with empirical values. The theoretical value of ζ for Ca XV is 24900 cm^{-1}, close to Garstang's extrapolated value. A.

523.854.1

4315. The theory of the fluctuations in brightness of the Milky Way. VI. G. MÜNCH. *Astrophys. J.*, **121**, *No.* 2, 291–9 (*March*, 1955).

For Pt V, see Abstr. 3235 (1952). The stochastic process defined by the surface brightness of the Milky Way in the discrete cloud model is further studied. The problem of finding the probability distribution for the joint occurrence of two specified values of the surface brightness when we observe parts of the system extending to two given distances is solved. The solution is obtained in terms of a set of functions $\{\Phi_n(u, t)\}$ governing the probability distribution of the brightness u, conditioned to the occurrence of exactly n clouds in a system of extent t. The covariance of the process is shown to be of a simple exponential type, with a decay constant equal to $(1-q)^{-1}$, q being the transparency factor of a cloud. Adopting values of q and ν (the mean number of clouds per unit distance) previously found, it is estimated that the distance over which the brightness fluctuations become effectively uncorrelated is 600 parsec. A.

523.872

4316. On a new parameter related to the electron density of a stellar atmosphere. S. TAFFARA. *Mem. Soc. Astron. Ital.*, **25**, *No.* 4, 393–9 (1954) In Italian.

An empirical relation is set up between the principal quantum number n of the last resolved Balmer line and the number n' for which the number of absorbing atoms in the second quantum state is a maximum. The relation of n' to electron density is then examined by using the Inglis–Teller formula and also by application of Holtsmark's theory. R. A. NEWING

523.872

4317. The effect of two-photon emission on the radiation field of planetary nebulae. II. B. YADA. *Publ. Astron. Soc. Japan*, *6*, *No.* 2, 76–86 (1954).

For Pt I, see Abstr. 1477 (1955). The effect is studied for larger opacities than in Pt I. The results of the calculations for three optical thicknesses, assuming a four-step function for the Lyman-α absorption coefficient, are discussed. A.

523.872

4318. Numerical table of the integral expressing the amount of absorption or emission of the spectral lines. K. ARAKI. *Publ. Astron. Soc. Japan*, **6**, *No.* 2, 109–12 (1954).

A numerical table of $\int_0^\infty [1-\exp(-\eta e^{-\xi^2})]d\xi$ is given for η from 0·01 up to 1×10^{10}. A.

523.872

4319. The Gaussian quadrature formula for an Elsasser band-absorption model. J. I. F. KING. *Astrophys. J.*, **121**, *No.* 2, 425–9 (*March*, 1955).

Under radiative equilibrium the emission coefficient of a narrow band-absorbing gas is equal to the frequency integral of the average intensity and the band-absorption coefficient. A two-point Gaussian quadrature formula is developed for this frequency integration, by using the Elsasser band of equally spaced, equally intense, Lorentz-broadened lines as the absorption model. By the use of this formula, the Chandrasekhar method of discrete ordinates can be extended to include an integration over frequency space as well as μ-space. Thus the effect of deviations from "greyness" in an atmosphere can be included directly in the radiative equilibrium formalism, without recourse to iterative procedures. A.

523.872 : 537.564

4320. Collisions between protons and metastable atoms or ions having outer p^q shells. M. J. SEATON. *Ann. Astrophys.*, **17**, *No.* 6, 550–4 (1954).

Proton impact may produce transitions between the metastable ground configuration terms of ions with outer p^q shells ($q = 2$, 3 or 4). It is shown, however, that under the conditions prevailing in gaseous nebulae the number of such transitions will be small compared with the number of transitions produced by electron impact. A.

523.877

4321. The energy production in convective cores of stars. P. NAUR. *K. Danske Vidensk. Selsk., matfys. Medd.*, **29**, *No.* 5, 14 *pp.* (1954).

Tables of the integral functions, $I_m(\xi)$, and $W_m(\xi)$, involving θ, the Lane–Emden function of index, $n = 3/2$, are given for all integral values of m between 1 and 23. The tabulated values of $I_m(\xi)$ facilitate the calculation of energy production in convective stellar cores; whilst those of $W_m(\xi)$ are intended primarily to aid in similar calculations where homologous invariant quantities form the primary variables. The tables of W have been computed with the argument ξ whereas integrations of stellar structure require V to be the independent variable. An auxiliary table is provided giving both U and ξ as functions of V over the range, $V = 0{\cdot}0$ to $3{\cdot}6$. D. R. BARBER

523.877

4322. Consideration of energy flow in the vibration of a stellar model. T. C. ROY. *Bull. Calcutta Math. Soc.*, **46**, *No.* 2, 87–92 (*June*, 1954).

Use is made of the energy equation instead of the condition of adiabacy. It is shown that for opacity law of a special kind if there be any stationary vibration of the stellar configuration there must be a node at the surface of the star for the velocity, thereby suggesting that there can be no wave of strictly stationary type. The situation does not arise when strict adiabacy is assumed. A.

523.877

4323. Inhomogeneous stellar models. IV. Models with continuously varying chemical composition. R. HÄRM AND M. SCHWARZSCHILD. *Astrophys. J.*, **121**, *No.* 2, 445–53 (*March*, 1955).

For Pt III, see Abstr. 1987 (1954). Nine sample models are constructed in which the mean molecular weight varies from the centre to the surface by a factor of 2·5 and in which this variation occurs continuously inside an intermediate zone. These models are compared with simpler models in which the same composition variation occurs discontinuously at an interface. The comparison shows that the simpler, discontinuous models may be used to compute the luminosity with satisfactory accuracy but they tend to exaggerate the radii—in certain cases by an order of magnitude. A.

523.877 : 523.841.1

4324. The pre-nova stage of a star. C. E. R. BRUCE. *Rep. Brit. Elect. Res. Assoc., Rep. Z/T*84, 9 *pp.* (1952).

Discusses the evidence bearing on the pre-nova stage of a star, and purports to show that this is inadequate to warrant the generally held view that the pre-nova stage is a star of early-type. Evidence is offered in support of the view that the pre-nova stage is a star of later type. It is pointed out that the electrical discharge theory of stellar surface phenomena offers an explanation for the bright emission lines in the absorption spectra of novae and late-type stars, and that recent work on the relation between the increase of brightness of novae and their brightness at maximum light, supports the view as to the distribution of magnitudes of pre-nova stage stars derived from the electrical discharge theory of these outbursts. A.

523.877 : 532.5

4325. The character of the instability of an incompressible fluid of constant kinematic viscosity and exponentially varying density. T. Y. TENG FAN. *Astrophys. J.*, **121**, *No.* 2, 508–20 (*March*, 1955).

The equations determining the rate of growth of a horizontal periodic disturbance (of a given wave number k) in an incompressible fluid of constant kinematic viscosity (ν) and exponentially varying density ($\rho = \rho_0 \exp[\beta z]$) are obtained. It is shown that this rate of growth depends on the two dimensionless parameters $L = l\beta$ and $G = g/\nu^2\beta^3$, where l is the depth of the fluid layer considered and g is the value of gravity. For a number of assigned values of L and G, the dependence of the growth rate on $\kappa(= k/\beta)$ is established, and the mode of maximum instability ($\kappa = \kappa_{max}$) is determined. For large or small values of G, simple asymptotic formulae for κ_{max} are derived. A.

523.877 : 538.6

4326. Stationary solutions of the magneto-hydrodynamical equations of interest in cosmogony. C. AGOSTINELLI. *R.C. Accad. Naz. Lincei*, **17**, *No.* 5, 216–21 (*Nov.*, 1954) In Italian.

A class of solutions for a uniform conducting liquid is derived in which the magnetic intensity $\boldsymbol{H} = \nabla\Phi - \boldsymbol{r}\times\nabla\Psi$ and the liquid velocity $\boldsymbol{v} = \boldsymbol{H}\sqrt{(\mu/4\pi\rho)}$, μ being the permeability and Φ an Ψ arbitrary harmonic functions. The solution for a uniformly rotating liquid magnetic star is included as a special case, and is generalized to the case in which there is a uniform field parallel to the axis of rotation in addition to a transverse field $\gamma_0 v\sqrt{(4\pi\rho/\mu)}$, where γ_0 is a constant. The equilibrium form of the star is flattened at the poles if $\gamma_0^2 < \frac{1}{2}$, but is extended if $\gamma_0^2 > \frac{1}{2}$. R. A. NEWING

PHYSICS 53

53 : 523.11

4327. Numerical coincidences in microphysics and cosmology. E. J. ZIMMERMAN. *Amer. J. Phys.*, **23**, *No.* 3, 136–41 (*March*, 1955).

If nuclear lengths, masses, times, energies, actions, etc., are compared with corresponding cosmological quantities, the resulting dimensionless ratios are near unity or near a small, half-integral power of 10^{80}, which is picturesquely called the "number of particles in the universe." These "numerical coincidences" are collected and shown to imply probably a single relation between atomic and cosmic structural constants. They may be used to define two systems of units such that any quantity has a measure in the "elementary" system which is an integral power of 10^{40} times its measure in the "cosmical" system. Both systems are theoretically convenient, the "elementary" having c and h unity, and the "cosmical" having c and G unity. A.

53.081

4328. A new system of logarithmic units. R. V. L. HARTLEY. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 1, 174–6 (*Jan.*, 1955).

The various units, e.g. the octave and the bel, which are in use and which each have their own magnitude and name are discussed with the object of finding a family of units. The author introduces the concept of primary and secondary units. For an arbitrary base a, the logarithm of any number x has the numerical value $\log_a x$ and the unit logarithm is $\log_a a$, the primary unit of the system. For the secondary unit an arbitrary number r is chosen and the magnitude of the secondary unit is $\log_a r$ so that x corresponds to N secondary units where $N = \log_r x$. The family to which a particular unit belongs is determined by the value of r which defines it. The question of attaching physical dimensions to x and of the choice of a suitable name for $(\log 10^{0\cdot1})$ are also discussed. Some applications of the new system are indicated. S. WEINTROUB

53.081.1

4329. The decilit: a new name for the logarithmic unit of relative magnitudes. V. V. L. RAO AND S. LAKSHMINARAYANAN. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 376–8 (*March*, 1955).

The standard magnitude ratio of $10^{0\cdot1}$ is accepted as a useful device for the specification of relative magnitudes. The significance of such a standard-magnitude ratio when considered as the basis of a unit is discussed. The name *decilit* is suggested. A.

53.082.7 : 621.315.2 : 621.317.18

4330. High noise cable as a sensing element. H. T. MERYMAN AND H. W. SHIRER. *Rev. sci. Instrum.*, **25**, *No.* 12, 1198–200 (*Dec.*, 1954).

The problem of devising a sensing element of the "burglar alarm" type which would be highly sensitive, portable, battery-operated and adaptable to any type of terrain was solved by using a shielded cable of high-noise characteristics as an extended transducer. By this means, a device of extreme simplicity was developed with sensitivity sufficient to detect almost indiscernible physical deflection. A

53.087.6

4331. Straightening curvilinear records. C. A. SHAIN. Note in *J. sci. Instrum.*, **32,** *No.* 3, 121–2 (*March*, 1955).

Many recording meters have the pen moving in a circular arc and there is considerable distortion of the record compared with a Cartesian representation. Such records can be rectified by a photographic process, by wrapping the record around a conical surface, with vertex directly underneath the camera lens and with one generator horizontal. A sample corrected record is shown. R. W. FISH

FUNDAMENTALS 530.1

530.112

4332. Proposal for a new æther drift experiment. D. D. CROMBIE. Letter in *Nature* [*London*] **175,** 350–1 (*Feb.* 19, 1955).

It is suggested that greater sensitivity could be obtained in the applications of microwave techniques proposed by Furth and Essen if the cavity resonator were used to produce a phase change in a signal from a fixed frequency oscillator rather than to control the oscillator frequency. R. A. NEWING

530.12

4333. On the centre of inertia in the general theory of relativity. M. F. SHIRKOV. *Zh. éksper. teor. Fiz.*, **27,** *No.* 2(8), 251–6 (1954) In Russian.

A relation is formulated which is covariant in the sense of the general theory of relativity and which defines a vector, analogous to the vector for the non-relativistic centre of inertia. For a system with a weak gravitational field an approximate formula is found for the co-ordinates of the centre of inertia which shows that it is determined by the distribution of the rest masses and of the masses corresponding to the kinetic and potential energies of the system calculated according to the usual relation between mass and energy. W. J. SWIATECKI

530.12

4334. Correction and completion of "On linear field theory." W. SCHERRER. *Z. Phys.*, **140,** *No.* 2, 160–3 (1955) In German.

The correction of a numerical error shows that the estimated age for the oscillating model universe previously considered [Abstr. 29 (1955)] is $<2{\cdot}2\times10^9$ years. The theory would give an acceptable age for a monotonic aperiodic model universe. R. A. NEWING

530.12

4335. On linear field theory. II. Weak fields. W. SCHERRER. *Z. Phys.*, **140,** *No.* 2, 164–80 (1955) In German.

The new field equations [see Pt I, Abstr. 29 (1955); see also preceding abstract] are given in detail in the 1st approximation for weak fields and their relation to the Maxwell vacuum equations is discussed. R. A. NEWING

530.12

4336. On a new definition of current and charge in Einstein's unified theory. S. MAVRIDÈS. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 4, 404–6 (*Jan.* 24, 1955) In French.

See Abstr. 7106 (1954).

530.12

4337. Field equations in general relativity. C. W. KILMISTER AND G. STEPHENSON. Letter in *Nuovo Cimento* (*Ser.* 10) **1,** *No.* 2, 361–2 (*Feb.*, 1955).

Attention is drawn to arbitrary assumptions involved in identifying the symmetric tensor of rank 2 occurring in the field equations with the contracted Riemann–Christoffel tensor. R. A. NEWING

530.12

4338. On the generalized field equations of Einstein and Schrödinger. J. WINOGRADZKI. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 9, 945–7 (*Feb.* 28, 1955) In French.

The equations arising from the simplest variation principle are considered. The equations satisfied by g_{ik} treated as a generalized field, are the conditions of compatibility of the equations determining Γ^i_{km}, and have an essential invariance character, which is not so of the Euler equations. If g_{ik} and Γ_i are considered as generalized fields, the physical equations are the Euler equations. P. T. MATTHEWS

530.12

4339. A new static spherically symmetric solution of Einstein's unified field theory. P. C. VAIDYA. Letter in *Proc. Phys. Soc.* [*London*] *A*, **68,** *Pt* 3, 260–2 (*March* 1, 1955).

It is noted that the derivation of the field equations from a variation principle does not require $|\mathfrak{g}^{ik}| \neq 0$. A solution is derived for the case $|\mathfrak{g}^{ik}| = 0$, and putting $g^{mn} = \mathfrak{g}^{mn}/\sqrt{(-|\mathfrak{g}^{ik}|)}$ a line element is derived in the form $ds^2 = \alpha\beta dt^2 - (\beta/\alpha)dr^2 - d\theta^2 - \sin^2\theta d\phi^2$, α and β being functions of r. R. A. NEWING

530.12 : 523.112

4340. On the cosmological constant. A. CARRELLI. *Mem. Soc. Astron. Ital.*, **25,** *No.* 4, 305–9 (1954) In Italian.

In a discussion of the physical significance of λ it is noted that this constant occurs in equations defining the interdependence of pressure and density in a non-static homogeneous universe. R. A. NEWING

530.12 : 530.145

4341. Relativistic motion in a scalar field. G. MARX AND G. SZAMOSI. *Bull. Acad. Polon. Sci. Cl.* 3, **2,** *No.* 10, 475–9 (1954).

The motion of a particle is considered in a field such that the world force is not orthogonal to the world velocity. The rest-mass is then of the form $m + \phi/c^2$, where ϕ is the potential of the scalar field, and the motion can be represented as non-relativistic motion with equivalent potential $\propto \phi + \phi^2/2mc^2$ [see also Abstr. 30 (1955)]. These considerations are applied to a nucleon moving under a central attraction; mass becomes negative for $\phi < -mc^2$ and the field is then effectively a repulsion. R. A. NEWING

530.12 : 536.7 : 538.3

4342. The field equations for an electromagnetic fluid-field system. The Cauchy problem for an electromagnetic fluid-field system. PHAM MAU QUÂN. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 6, 598–600 (*Feb.* 7); *No.* 7, 733–5 (*Feb.* 14, 1955) In French.

The energy-momentum tensor is generalized to include both electromagnetic and thermodynamic terms. The Cauchy problem is discussed for the case of a perfect fluid. R. A. NEWING

530.145

4343. Order of magnitude of the field mass of a nucleon in a non-linear meson field theory. M. Miasek and A. Legatowicz. *Bull. Acad. Polon. Sci. Cl.* 3, **2**, *No.* 10, 481–4 (1954).

Corresponding to Born–Infeld non-linear electrodynamics, a class of non-linear meson theories is investigated which reduce to the linear case for weak fields and where the field energy density is finite everywhere and has its maximum at the centre of the particle. The static scalar case with spherical symmetry is treated here. If the range of the non-linear modification of the field is assumed to be of the order of magnitude of nuclear dimensions, the "field mass" of the nucleon amounts to about 1/137 of the whole nucleon mass. G. FIELD

530.145

4344. On differential structure of non-local field theories. J. Rzewuski. *Bull. Acad. Polon. Sci. Cl.* 3, **2**, *No.* 9, 429–33 (1954).

See Abstr. 7110 (1954). The case of partial integro-differential equations arising in non-local field theories is studied. The initial value problems are solved for linear and non-linear systems which are local in time, but non-local in space-like directions. G. FIELD

530.145

4345. Equivalence of the Lagrangian formulations of quantum field theory due to Feynman and Schwinger. W. K. Burton. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 2, 355–7 (*Feb.*, 1955).

530.145

4346. State vector and quantization in an over-all space-time view. J. G. Valatin. *Proc. Roy. Soc. A*, **229**, 221–34 (*April* 21, 1955).

The state vector of a quantized system of fields is defined as a functional of external source functions. Physical quantities are related to operators acting on such functionals. This corresponds to an over-all space-time view in which the state describes a space-time evolution and the state vector is not related to any special space-like surface. The field equations are derived by means of a simple formal quantization and are expressed as supplementary conditions restricting the state functionals. The equations are satisfied by generating functionals defined in the three-dimensional operator theory and were given previously. An investigation of the concept of functionals of anticommuting source functions leads immediately to the consideration of an antisymmetric tensor space with its creation and annihilation operators. The creation and annihilation operators introduced by Coester correspond to another representation and the connection can be easily established. The relationship between different formal solutions of the field equations given by Coester, Nambu and Anderson, and Skyrme is made apparent. An interchange of the rôle of creation and annihilation operators, which amounts to a functional Fourier transformation, leads to an alternative description in which the state vector of the quantized system is given by a functional of fields which are functions of the four space-time co-ordinates. A.

530.145

4347. On the diagonalization of the dipole Hamiltonian of free and bound electrons in an electromagnetic radiation field. H. Steinwedel. *Ann. Phys.* [*Leipzig*] **15**, *No.* 3–4, 207–23 (1955) In German.

The diagonalization of the Hamiltonian of a non-relativistic electron coupled with the dipole components of the radiation field is carried out by a method different from that of van Kampen [see Abstr. 4142 (1952)]. The derivations of the equations for eigenvalues and phases and of the canonical transformation and its inverse do not involve summation of infinite series by this method. G. FIELD

530.145

4348. Finite parts of Riemann–Weyl integrals and regularization processes. A. Gonzàlez Dominguez. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 5, 499–500 (*Jan.* 31, 1955) In French.

The concept of the finite part of a divergent Riemann–Liouville integral is used to establish a regularization formula. As an example, Gupta's result for the photon self-energy is obtained. G. FIELD

530.145

4349. On the renormalization in Tamm–Dancoff approximation for one-nucleon problem. II. Subtraction of divergences in the generalized Tamm–Dancoff equations. K. Itabashi. *Progr. theor. Phys.*, **12**, *No.* 5, 585–602 (*Nov.*, 1954).

For Pt I, see Abstr. 3432 (1955). The essence of the method is the extension of Fubini's procedure to arbitrarily higher order approximation. That is, first, formal solutions are constructed which satisfy the equations in question; they contain infinities and accordingly are quite meaningless. Then the infinities (including overlapping divergences) are separated individually at each stage of the construction of these formal solutions. The forms of the nucleon propagation function or the vertex parts which have been made convergent by this method depend on the configurations to which they refer. However, this seems to be inevitable for the present approximation method, i.e. the reduction of an infinite set of coupled integral equations to a finite one. A.

530.145

4350. Renormalization of two-electron Green-function. S. Sunakawa, T. Imamura and R. Utiyama. *Progr. theor. Phys.*, **12**, *No.* 5, 642–52 (*Nov.*, 1954).

The difference between the ordinary method of renormalization of Dyson and that of the present authors developed in a previous paper [Abstr. 2945 (1953)] is emphasized. In order to clarify this difference, the renormalization of the two-electron Green-function is investigated. The proof of the finiteness of the renormalized Green-function seems to be quite brief. An essential point in this proof is that there is no ambiguity in the order of integration appearing in the course of calculation of Green-functions. A.

530.145

4351. Remarks on the existence of derivatives of propagation kernels with respect to the interaction strength. E. R. Caianiello. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 2, 337–40 (*Feb.*, 1955).

The existence is proved of all the derivatives with

respect to the coupling constant, λ, of propagation kernels, provided the latter exist and are continuous at $\lambda = 0$. P. T. MATTHEWS

530.145

4352. Many-body forces and non-linear interactions. E. CLEMENTEL AND C. VILLI. *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 2, 344–6 (*Feb.*, 1955).

A discussion to what extent these two approaches, used in attempts to account for nuclear saturation, are equivalent. An explicit example with many-body Wigner-type forces turns out to give the same interaction energy as a simple non-linear theory. W. J. SWIATECKI

530.145

4353. Virtual masses of interacting fields. R. SHAW. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 3, 519–21 (*March*, 1955).

It is shown, for the case of a neutral interacting field, that the parts corresponding to the various masses [cf. Abstr. 5288 (1954)] can be separated off invariantly, and that, as far as vacuum expectation values of quadratic quantities are concerned, these parts behave like free fields, only their strengths being determined by the coupling. W. A. HEPNER

530.145

4354. Infrared divergence in bound state problems. F. ROHRLICH. *Phys. Rev.*, **98**, *No.* 1, 181–2 (*April* 1, 1955).

The proof, in the interaction solution, that all infrared divergences exactly cancel for all physical processes and to all orders in the coupling constant, leads to apparent difficulties in bound state problems. These difficulties are resolved. A.

530.145

4355. Variation calculation of the polarizability of the deuteron. B. W. DOWNS. *Phys. Rev.*, **98**, *No.* 1, 194–6 (*April* 1, 1955).

The polarizability of the deuteron in a uniform electric field is calculated by a variation method. The result obtained by Ramsey, Malenka and Kruse is rederived and improved in accuracy, and the modification of the deuteron wave-function produced by the electric field is calculated. A.

530.145

4356. The magnetic moment of the proton. I. ÚLEHLA. *Czech. J. Phys.*, **4**, *No.* 3, 267–76 (*Sept.*, 1954).

The magnetic moment of a bare proton is calculated in a non-relativistic approximation on the condition that the proton is a particle which is capable of existing not only in a state with spin $\frac{1}{2}$ but also in a state with spin $\frac{3}{2}$. A.

530.145

4357. An empirical "charge dependence" relation to the rest-masses of elementary particles. S. YOSHIKAWA AND T. HASEBE. Letter in *Progr. theor. Phys.*, **12**, *No.* 3, 403–6 (*Sept.*, 1954).

Following a previous account of obtaining a mass spectrum with computed masses μ_n [Abstr. 49 (1955)], an empirical formula is put forward relating μ_n to the masses of neutral (m_0) and charged (m_{ch}) particles. $\mu_n = m_{ch} + (-1)^{2T}\delta m$ where $\delta m = (2/\pi)(m_{ch} - m_0)$ and T the total isotopic spin of the particle. The cases of π and τ mesons, nucleons and V_1 particles are discussed in the light of this formula. G. FIELD

530.145

4358. The algebra of isotopic spins (3/2, 1/2). V. VOTRUBA AND C. J. CHRISTOV. *Czech. J. Phys.*, **4**, *No.* 4, 403–18 (*Nov.*, 1954) In German.

All irreducible systems of n Hermitian matrices, which satisfy the cyclic commutation relation of the third order, are found explicitly. For $n > 3$ the only non-trivial solution also satisfies the Kemmer relations. P. T. MATTHEWS

530.145

4359. On the expansion in Fourier integrals of the wave-functions of particles of [arbitrary] spin. R. POTIER. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 3, 281–3 (*Jan.* 17, 1955) In French.

The results of Costa de Beauregard [Abstr. 1519 (1955)] on bare particle propagators of particles obeying the Dirac and Klein–Gordon equations are extended to cover particles of arbitrary spin. The method is independent of the particular form the wave equation takes in these cases. G. FIELD

530.145

4360. Connection between Dirac's electron and a classical spinning particle. F. GÜRSEY. *Phys. Rev.*, **97**, *No.* 6, 1712–13 (*March* 15, 1955).

A connection is established between the classical and wave mechanics of a spinning relativistic particle. In the case of a plane wave comprising both positive and negative energies, the 4-dimensional stream-lines of the current density 4-vector coincide with the world-lines of a classical particle. Moreover, the wave-function represents the spinor (or quaternion) which determines the generalized intrinsic frame of reference attached to the world-line of the classical particle. This provides a geometrical interpretation for the unquantized Dirac field as well as for the total angular momentum. A.

530.145

4361. The effect of radiative corrections on a charged spin 1/2 particle in a constant magnetic field. A. H. DE BORDE. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 316–21 (*April*, 1955).

As an alternative approach to the problem of determining magnetic moments the S-matrix formalism for a Dirac particle in an electromagnetic field is re-expressed as an integral equation of the Feynman type for a one-electron wave-function. For a constant magnetic field, the equation reduces to a differential equation which may be solved for the energy eigenvalues in a non-relativistic approximation with arbitrary radiative correction terms. Provided conditions resulting from gauge invariance are satisfied, application of charge renormalization shows that the cyclotron frequency is unaltered in all orders. The magnetic moment derived is the same as that derived direct from the S-matrix. A.

530.145

4362. Spin polarization of the deuteron. W. LAKIN. *Phys. Rev.*, **98**, *No.* 1, 139–44 (*April* 1, 1955).

Methods of specifying the state of polarization of a particle of spin 1 are discussed. Selection rules for

polarization effects in simple nuclear reactions are derived; in general four parameters are needed to describe the deuteron polarization due to such reactions. Methods of determining these parameters include the use of magnetic deflection. A rough analysis is made of the polarization of deuterons scattered by carbon. A.

530.145 : 537.122

4363. On the theory of the electron. IV. W. WESSEL. *Z. Naturforsch.*, **10a,** *No.* 2, 89–103 (*Feb.*, 1955) In German.

For Pt III, see Abstr. 1368 (1953). A method is developed for the determination of the eigenvalues of the mass operator after rationalization based on the principle of correspondence. The eigenvalues depend on the fine structure constant and, for spin $\frac{1}{2}$, are very near to the eigenvalues ± 1 of the mass operator of Dirac's theory. The remaining difficulty that the eigenvalues have a small imaginary part is attributed to the one-particle character of the theory. L. PINCHERLE

530.145 : 538.3

4364. The use of real spinors for the description of the electromagnetic field. G. A. ZAĬTSEV. *Zh. éksper. teor. Fiz.*, **25,** *No.* 6(12), 675–8 (1953) In Russian.

Real spinors [see Abstr. 2410–11 (1955)] are used to describe an electromagnetic field for which $\mathbf{E}^2 - \mathbf{H}^2 = 0$, $\mathbf{E} \cdot \mathbf{H} = 0$ and the direction of propagation is constant. A mathematical analogy, believed to be more profound than usually assumed, appears in the description of this field and that of spin $\frac{1}{2}$ particles. Thus Maxwell's equations go over into the Dirac equation with zero mass, in which there enters not a spin-tensor but the components of a real spinor. W. J. SWIATECKI

530.145

4365. A remark on Tamm–Dancoff approximation. T. OKABAYASHI. Letter in *Progr. theor. Phys.*, **12,** *No.* 4, 545–6 (*Oct.*, 1954).

The case of a two-nucleon system interacting with a meson field, in the absence of nucleon pairs, is used as an illustration that the Tamm–Dancoff approximation is essentially a bound-state approximation. The more general case, with an arbitrary number of nucleon pairs and a single meson, is also discussed. G. FIELD

530.145

4366. On the multiple scattering phase shifts and the nuclear force (scalar pair theory). K. HASEGAWA AND S. AZUMA. Letter in *Progr. theor. Phys.*, **12,** *No.* 4, 546–7 (*Oct.*, 1954).

This is an extension of a result obtained by Sawada (1953) showing the connection between the self-energy, ΔE, of a fixed nucleon source and scattered meson-wave phase shifts, δ_l: $\Delta E = -(2\pi)^{-1} \int_0^\infty dk (k/e_k) \sum_l \delta_l(k)$, where $e_k = (\mu^2 + k^2)^{\frac{1}{2}}$ and μ is the meson rest-mass. Two fixed nucleon sources are considered here, in scalar pair theory with scalar coupling. The same relation is also obtained for this case. G. FIELD

530.145

4367. On the effects of excited states of nucleons upon static nuclear potential in symmetrical pseudoscalar meson theory. II. Numerical results on deuteron problem. T. MATSUMOTO AND M. SUGAWARA. *Progr. theor. Phys.*, **12,** *No.* 5, 553–60 (*Nov.*, 1954).

For Pt I, see Abstr. 4181 (1954). Numerical results of the deuteron problem which were carried out by Illiac computer at the University of Illinois are presented for the potential derived in Pt I and the one derived by Taketani *et al.* These potentials, and also the one recently derived by Brueckner and Watson have a tensor force of right sign of almost the same magnitude, but they are quite different from each other with respect to their central parts: Taketani's is strongly repulsive, the present authors' weakly attractive and Brueckner and Watson's strongly attractive. The radius of hard core was chosen as 0·3, 0·383 and 0·466 in units of meson Compton wavelength. Firstly, the numerical factor multiplying the potential is adjusted so as to give the correct binding energy. Then other quantities are calculated. The numerical results show that the relative weight of the central force to the tensor force in the authors' potential is too small because it gives too large a quadrupole moment, and a *D*-state probability approximately three or four times as large as the empirical values. In Taketani's case the deuteron cannot bind, because the repulsive central force is too large compared with the tensor force. Thus it can be concluded that an attractive central force at least of the same order of magnitude as the tensor force is necessary in order to obtain agreement with empirical data in the deuteron problem. A.

530.145

4368. Diagonalization of Hamiltonian and Tamm–Dancoff equation. S. ÔKUBO. *Progr. theor. Phys.*, **12,** *No.* 5, 603–22 (*Nov.*, 1954).

A formalism where the Hamiltonian is generally diagonalized is given and the relation of this formalism to the Tamm–Dancoff equation is studied. The Tamm–Dancoff equation in which the energy of the system appearing in the denominator of the equation is eliminated, can be obtained from the solution of a differential equation. In this energy-eliminated Tamm–Dancoff equation, the subtraction of closed loops is possible. Some applications are given. A.

530.145

4369. On Tomonaga's method of treating fields with intermediate coupling. Methodical studies. I. G. HEBER. *Ann. Phys.* [*Leipzig*] **15,** *No.* 3–4, 157–73 (1955) In German.

Tomonaga's intermediate coupling method is illustrated by treating a real scalar field coupled scalarly to scalar sources. Different cases are dealt with: fixed source, single moving source, non-relativistic source field. For the latter case it is shown that the self-energy of the source field remains finite in general, but then depends on the normalization volume. G. FIELD

530.145

4370. Tomonaga's method of treating fields with intermediate coupling. Methodical studies. II. G. HEBER. *Ann. Phys.* [*Leipzig*] **15,** *No.* 3–4, 174–7 (1955) In German.

A continuation of the work of the preceding

abstract. The rôles of the normalization volume and the state of the source field are investigated. It is found that only the state of the field (e.g. momentum distribution) has a meaningful influence on final results (such as self-energy). G. FIELD

530.145

4371. Intermediate-coupling interaction of a non-relativistic particle with a scalar field. I. G. HÖHLER. *Z. Phys.*, **140**, *No.* 2, 192–214 (1955) In German.

The ground-state energy of a non-relativistic particle, coupled with arbitrary strength to a scalar field, is calculated by a new variational method combining the advantages of Pekar's method with those of Gurari and of Lee, Low and Pines. It represents a generalization of Tomonaga's intermediate coupling method. An application to the theory of conduction electrons in polar crystals is briefly discussed. T. P. BRODY

530.145

4372. The interaction of many particles. I. General theory. H. KÜMMEL. *Z. Naturforsch.*, **10a**, *No.* 2, 117–25 (*Feb.*, 1955) In German.

The many-particle Bethe–Salpeter equation is derived and discussed with regard to specific problems arising from the presence of many particles. In the limit of non-relativistic particles and the ladder approximation, the Bethe–Salpeter equation goes over into the Hartree–Fock equations. The relation to the self-consistent field method of Kinoshita and Nambu [Abstr. 6303 (1954)] is examined. P. T. MATTHEWS

530.145

4373. Nucleon-nucleus potential at high energies. E. CLEMENTEL. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 3, 509–11 (*March*, 1955).

Assuming the impulse approximation and the Serber picture, it is shown that the potential experienced by a nucleon in collision with a nucleus can be split into a central and a spin-orbit part, the radial dependence of the latter being just of the form given by the Thomas precession. P. T. MATTHEWS

530.145

4374. Noncoherent scattering due to collisions. I. Zanstra's ratio of coherent to uncorrelated non-coherent scattering. F. N. EDMONDS, JR. *Astrophys. J.*, **121**, *No.* 2, 418–24 (*March*, 1955).

A quantum-theory formulation of the problem of non-coherent scattering due to collisions is presented in a general form and then made equivalent to Zanstra's classical oscillator formulation by a set of assumptions. These assumptions are examined critically as an indirect method of determining whether Zanstra's results are correct for statistical broadening. It would seem that Zanstra's ratio of coherent to uncorrelated non-coherent scattering is too large by at least a factor of 20, and the coherent component is not strictly coherent. The validity of evaluating Zanstra's results for impact broadening by this method is briefly discussed. A.

530.145

4375. On the infinity in the second Born approximation for the Coulomb field. L. R. B. ELTON. *Proc. Cambridge Phil. Soc.*, **51**, *Pt* 2, 333–43 (*April*, 1955).

It is shown that the infinity arising in the second Born approximation to the scattering amplitude of a particle scattered by a Coulomb field is due to the distortion at infinity of Coulomb waves. Ways of subtracting out this infinity, which does not lead to any observable effects, are indicated. A.

530.145

4376. Lower limit for the energy derivative of the scattering phase shift. E. P. WIGNER. *Phys. Rev.*, **98**, *No.* 1, 145–7 (*April* 1, 1955).

It is shown that the derivative of the scattering phase shift with respect to energy, $d\eta/dE$, must exceed a certain limit if the interaction of scattered particle and scatterer vanishes beyond a certain distance. This limitation of $d\eta/dE$ is, fundamentally, a consequence of the principle of causality; it is derived, however, from a property of the derivative matrix R. A.

530.145

4377. Scattering of polarized nucleon beams. R. OEHME. *Phys. Rev.*, **98**, *No.* 1, 147–53 (*April* 1, 1955).

The polarization formulae for the general reaction $a + b \rightarrow c + d$ are given in a compact form and specialized for the scattering of polarized nucleon beams at unpolarized targets. These targets may have arbitrary spin, possibly being different before and after collision. An interesting quantity in this problem is the polarization of the scattered nucleon beam. On the basis of general invariance properties of the transition matrix, this polarization is expressed by the polarization of the incoming nucleon beam and the relative momenta before and after collision. The invariant coefficients in this relation are functions of energy and scattering angle only; they are given in terms of the parameters of the transition matrix. By using these formulae, it is shown that with triple scattering experiments one can obtain two new relations between the parameters of the transition matrix at fixed energy and angle. Quadruple scattering leads to two further relations. These relations represent information in addition to the differential cross-section and the polarization resulting from unpolarized beams. The results are specialized for targets of spin zero and spin one-half, where in the latter case also the scattering of identical particles is discussed briefly. A.

530.145

4378. Variational principle for scattering with tensor forces. S. I. RUBINOW. *Phys. Rev.*, **98**, *No.* 1, 183–7 (*April* 1, 1955).

A reformulation of the variational principle in differential form for the phase shift δ_l of a central-force scattering problem is presented. This is considered to be the most simple that can be formed in terms of the inside-wave-function representing the difference between the wave-function and appropriately chosen asymptotic form. It is then generalized by means of matrix notation so as to provide corresponding variational principles for the three parameters that arise in scattering with tensor forces, the two phase shifts $\delta\alpha$, $\delta\beta$ and the mixture parameter ε. These all develop from the differential formulation of Schrödinger's equation and do not depend on the integral equation formulation as does the one originally

presented by Schwinger for the phases δ_α and δ_β, and the extension of it by Blatt and Biedenharn to the parameter ε. A.

530.145

4379. Equivalent two-body method for the triton. H. Feshbach and S. I. Rubinow. *Phys. Rev.*, **98**, *No.* 1, 188–93 (*April* 1, 1955).

A method for developing equivalent two-body problems for the binding energy of the triton has been derived from the variational principle. The method has been applied to two central-force problems. In the first, the exponential well of Rarita and Present is discussed and the method is shown to give excellent results. In the second, the central-force term in the Lévy potential including the repulsive core is investigated. It is estimated that the Lévy potential including the tensor term will give the correct order of binding energy to the triton. A.

530.145

4380. Remarks on the hydrodynamical representation and certain generalization of quantum mechanics. T. Takabayasi. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 1, 257–9 (*Jan.*, 1955).

Comments are passed on various attempts to give a hydrodynamical model of quantum mechanics, and the relation between some of these is briefly discussed. About twelve papers which deal with the model are mentioned. P. T. Landsberg

530.145

4381. On the determination of wave-functions with local singularities in the theory of the double solution in some cases with simple limit conditions. G. Petiau. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 8, 848–50 (*Feb.* 21, 1955) In French.

The functions occur in de Broglie's theory of the double solution and are zero on the surfaces of various simple figures of revolution. They are solutions of Gordon's equation, and are expressible in terms of Bessel functions of half-integral order. Application is made to the motion of a particle moving along the axis of a cylindrical waveguide. L. S. Goddard

530.145

4382. On the problem of energy eigenvalue and degeneracy in quantum mechanics. H. Narumi. *Phil. Mag.*, **46**, 293–4 (*March*, 1955).

Both quantities can be deduced from the knowledge of a set of operators that commute with the Hamiltonian. Application to the Balmer formula.

W. A. Hepner

530.145

4383. Quantum theory of many-particle systems. I. Physical interpretations by means of density matrices, natural spin-orbitals, and convergence problems in the method of configurational interaction. P.-O. Löwdin. *Phys. Rev.*, **97**, *No.* 6, 1474–89 (*March* 15, 1955).

In order to calculate the average value of a physical quantity containing also many-particle interactions in a system of N antisymmetric particles, a set of generalized density matrices are defined. In order to permit the investigation of the same physical situation in two complementary spaces, the Hermitean density matrix of order k has two sets of indices of each k variables, and it is further antisymmetric in each set of these indices. Every normalizable antisymmetric wave-function may be expanded in a series of determinants of order N over all ordered configurations formed from a basic complete set of one-particle functions ψ_k, which gives a representation of the wave-function and its density matrices also in the discrete k-space. The coefficients in an expansion of an eigenfunction to a particular operator may be determined by the variation principle, leading to the ordinary secular equation of the method of configurational interaction. It is shown that the first-order density matrix may be brought to diagonal form, which defines the "natural spin-orbitals" associated with the system. The situation is then partly characterized by the corresponding occupation numbers, which are shown to lie between 0 and 1 and to assume the value 1, only if the corresponding spin-orbital occurs in all configurations necessary for describing the situation. If the system has exactly N spin-orbitals which are fully occupied, the total wave-function may be reduced to a single Slater determinant. However, due to the mutual interaction between the particles, this limiting case is never physically realized, but the introduction of natural spin-orbitals leads then instead to a configurational expansion of most rapid convergence. In case the basic set is of finite order M, the best choice of this set is determined by a form of extended Hartree–Fock equations. It is shown that, in this case, the natural spin-orbitals approximately fulfil some equations previously proposed by Slater. A.

530.145

4384. Quantum theory of many-particle systems. II. Study of the ordinary Hartree–Fock approximation. P.-O. Löwdin. *Phys. Rev.*, **97**, *No.* 6, 1490–508 (*March* 15, 1955).

A system of N antisymmetric particles, moving under the influence of a fixed potential and their mutual many-particle interactions, is investigated in the ordinary Hartree–Fock scheme, having the total wave-function approximated by a single Slater determinant. It is shown that all the density matrices of various orders, the wave-function, and the entire physical situation depends only on a fundamental invariant $\rho(x_1, x_2)$, which is identical with the first-order density matrix. The Hartree–Fock equations are expressed in terms of this quantity. The Hartree–Fock equations are also solved by expanding the eigenfunctions in a given complete set; and applications to the MO-LCAO theory of the electronic structure of molecules, and crystals are given. It is shown that, in this scheme, the entire physical situation depends on a charge and bond order matrix $R(\nu\mu)$ with respect to the ordinary atomic spin-orbitals involved. The Hartree–Fock equations for this matrix are investigated. Finally, the ionized and excited states are investigated, and it is shown that the Hartree–Fock scheme has a high degree of physical visuality also in case of many-particle interactions. The excitation energy of the system is the difference $(\omega_j' - \omega_i)$ between two "spin-orbital energies," being eigenvalues to the effective Hamiltonians associated with the two states under consideration. A.

530.145

4385. Quantum theory of many-particle systems. III. Extension of the Hartree–Fock scheme to include degenerate systems and correlation effects. P.-O. LÖWDIN. *Phys. Rev.*, **97**, *No.* 6, 1509–20 (*March* 15, 1955).

In treating a system of N antisymmetric particles, it is shown that, if the total Hamiltonian $\mathcal{H}_{op}$ is degenerate, the eigenstates of the operator used for classifying the corresponding degenerate states may be selected by means of a "projection operator" $\mathcal{O}$. If the total wave-function is approximated by such a projection of a single determinant, the description of the system may be reduced to the ordinary Hartree–Fock scheme treating this determinant, if the original Hamiltonian is replaced by a complete Hamiltonian $\Omega_{op} = \mathcal{O}\dagger \mathcal{H}_{op}\mathcal{O}$ containing also many-particle interactions. This approach corresponds to a "fixed" configurational interaction, but the scheme has preserved the physical simplicity and visuality of the Hartree–Fock approximation. The idea of "doubly filled" orbitals is abandoned and the orbitals associated with different spins will automatically try to arrange themselves in such a way that particles having antiparallel spins will tend to avoid each other due to their mutual repulsion. A.

530.145

4386. Derivation of the Feynman–Dyson rules from time-independent theory. S. T. EPSTEIN. *Phys. Rev.*, **98**, *No.* 1, 196–8 (*April* 1, 1955).

The Feynman–Dyson rules for computing the scattering matrix are derived starting with the time-independent Schrödinger equation. Although no essentially new results are obtained, it is interesting to trace the connection between the time-dependent and time-independent methods starting from the time-independent end rather than, as is usually done, starting from the time-dependent interaction representation. In particular, a theorem due to R. J. Eden plays an important rôle in the discussion. A.

530.145

4387. The wave equation for spin 1 in Hamiltonian form. E. SCHRÖDINGER. *Proc. Roy. Soc. A*, **229**, 39–43 (*April* 5, 1955).

If from the differential equations that hold in a Proca field the ten are selected that express the time derivatives of the ten components involved, i.e. of the "electromagnetic" field and its potential vector, then one obtains right away for the ten-componental entity an equation that may be said to be at the same time of the Schrödinger, the Dirac and the Kemmer type. The four 10×10 matrices that occur as coefficients are Hermitian and satisfy Kemmer's commutation rules. The fifth is easily constructed. Those of the Proca equations that were not included are merely injunctions on the initial value. They are expressed by one matrix equation, that makes it evident that, once posited, they are preserved. The three spin matrices are indicated. The spin number is 1 or 0, but the aforesaid injunctions exclude 0. A.

530.145 : 536.7

4388. Thermodynamics and quantum mechanics. A. GAMBA. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 2, 358–60 (*Feb.*, 1955).

Von Neumann's result on the entropy change through measurement on a system is discussed in connection with the equivalence of information and negative entropy. W. A. HEPNER

530.162

4389. On a deviation from the Boltzmann distribution. H. FALKENHAGEN AND G. KELBG. Note in *Naturwissenschaften*, **42**, *No.* 1, 10 (1955) In German.

The advantage of the Born–Green approximation is shown for a mixture of large and small spherical particles. T. C. TOYE

530.162

4390. On the structure of the configuration integral in the statistical mechanics of pure fluids. B. WIDOM. *J. chem. Phys.*, **23**, *No.* 3, 560–8 (*March*, 1955).

A form for the configuration integral is postulated. Its most important feature is the location of its zeros and poles in the complex volume plane. These lie on a contour which divides the real axis into distinct regions. The pressure, being expressed as an integral taken over this contour, can have different analytic forms on different parts of the real volume axis. It is shown that the asymptotic nature of a configuration integral of the assumed form is determined by the $p-v$ isotherms it produces, and the theory is worked out for isotherms derivable from a function of the van der Waals type with a classical critical point. The contour on which the zeros and poles of the configuration integral lie, and the density with which they are distributed, are determined explicitly in terms of these isotherms. The theory is illustrated in detail in the case of a simple equation of state. A.

530.162

4391. The effect of a potential gradient on the density of a degenerate Fermi gas. W. J. SWIATECKI. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 285–93 (*April*, 1955).

By studying the properties of a degenerate gas in a linearly varying potential a modified relation is derived between density and potential which replaces the usual $\rho = \text{const.}\ V^{3/2}$, takes into account explicitly the presence of potential gradients and can be used in regions of negative kinetic energy. When combined with Poisson's equation this gives a modified Thomas–Fermi differential equation. The resulting change in the density distribution of electrons in an atom is most marked in the outer regions, where the new equation leads to an $r^{-2}\exp(-r/a)$ decrease of density for a neutral atom. Applications to nuclear surface problems are mentioned. A.

530.162 : 539.11

4392. Relation between canonical and microcanonical ensembles. M. LAX. *Phys. Rev.*, **97**, *No.* 6, 1419–20 (*March* 15, 1955).

The equivalence of averages calculated in canonical and microcanonical ensembles is shown to depend on the validity of a steepest-descent approximation. It is demonstrated that the microcanonical and canonical procedures yield different values for the order parameter below the Curie temperature for spherical model dipole lattices. A.

530.19

4393. Principle of detailed balance. M. J. KLEIN. *Phys. Rev.*, **97**, *No.* 6, 1446–7 (*March* 15, 1955).

This note answers a question raised by Lloyd and

Pake as to whether or not the principle of detailed balance applies in non-equilibrium steady states. It is shown that detailed balance holds only at equilibrium, and that non-equilibrium steady states must be maintained by cyclic processes. A.

GENERAL MECHANICS
MECHANICS OF SOLIDS 531

531.24

4394. Centroidally bordered bodies and the balancing *L*. M. A. MELVIN. *Amer. J. Phys.*, **23**, *No.* 3, 131–5 (*March*, 1955).

The preparation of bodies which have the property that the mass centre lies on the periphery is here considered. It is demonstrated that, starting from a large variety of shapes, including all those here called "medially convex," it is always possible to prepare a centroidally bordered shape by cutting a simple triangular notch out of the basic shape. Incidentally it is proved that every area which is medially convex with respect to a base b is at least 8/3 times as great as the area of the centroid triangle constructed on the base b. The method of triangular notching is applied in detail to several familiar shapes, including the general trapezoid and circular segment. The preparation of a centroidally bordered shape from a basic shape which includes a straight angle in its boundary is also considered. The solution by quadrilateral notching is indicated but not carried through in detail. The simple solution for the special case of the balancing *L* is written down and illustrated photographically. A.

531.258

4395. Plane deformation in the non-linear theory of elasticity. F. KROUPA. *Czech J. Phys.*, **5**, *No.* 1, 18–29 (*Feb.*, 1955).

A definition and discussion is presented, with reference to rubber. From the fundamental equations given, a special case is studied for rotational symmetry, and the torsional damper is solved according to the non-linear static theory of elasticity. A.

531.259

4396. Finite deformation of materials exhibiting curvilinear aeolotropy. J. E. ADKINS. *Proc. Roy. Soc. A*, **229**, 119–34 (*April* 5, 1955).

Using tensor notation, a general theory is developed for finite elastic deformations of compressible and incompressible materials which exhibit curvilinear aeolotropy. The theory is formulated for materials which are completely unsymmetrical, orthotropic or transversely isotropic with respect to the curvilinear co-ordinate system which is employed to define the aeolotropy. In applications, attention is confined to cylindrically symmetrical and spherically symmetrical problems, from which emerge as special cases the inflation, extension and torsion of a cylindrical tube, and the inflation of a spherical shell. In addition, the flexure of a cuboid of rectilinearly aeolotropic material is considered as a limiting case of the cylindrically symmetrical problem. The conditions for the tube or spherical shell to be everted, and for the curved faces of the deformed cuboid to be free from applied stress, are obtained in terms of a general strain-energy function in forms which are independent of symmetries in the material. A.

MECHANICAL MEASUREMENTS 531.7

531.717.1 : 541.64

4397. Maximum sensitivity in pneumatic gauging. N. R. WYNN; N. STOLOW. Letters in *J. sci. Instrum.*, **32**, *No.* 4, 155 (*April*, 1955).

The first author points out with reference to the paper [Abstr. 770 (1955)] by the second that the condition for max. sensitivity when a null-point method is used in pneumatic gauging is obtained when $H_{eff} = \frac{1}{2} H$. The second author argues, however, that this is correct for one application of the gauging method but not for the practical operation of his apparatus. W. GOOD

531.781 : 537.228.1

4398. Piezoelectric force measurement. H. H. RUST AND J. KROHN. *Z. angew. Phys.*, **7**, *No.* 2, 61–7 (1955) In German.

Static forces are measured by the charge generated on a quartz crystal; a condenser whose capacity varies sinusoidally with a high frequency is connected across the quartz and the potential is fed into a valve amplifier. Small forces can be measured and the decay of the charge on the quartz studied. J. M. HOUGH

531.787

4399. A new type of absolute manometer. R. G. NESTER. Note in *Rev. sci. Instrum.*, **25**, *No.* 11, 1136–7 (*Nov.*, 1954).

This is made of Pyrex glass and incorporates a leak-proof needle valve made of Teflon tetrafluoroethylene resin in place of a sealed-off closed end. The end of the Teflon valve is ground to 60°, and provides an absolutely tight seal. It is claimed that the construction simplifies the operations of filling, degassing and cleaning. J. S. G. THOMAS

531.787

4400. Bibliography and index on dynamic pressure measurement. W. G. BROMBACHER AND T. W. LASHOF. *Circ. Nat. Bur. Stand.*, *No.* 558, 124 *pp.* (1955).

Contains a bibliography of 850 items on dynamic pressure measurement and, in less detail, on related subjects such as static pressure measurement and general information on the components of instruments. A.

531.787 : 536.423.15

4401. A combination of a quartz-fibre with a Knudsen manometer for the determination of vapour-pressure curves of organic substances. H. KIEFER AND B. ZIEGLER. *Z. angew. Phys.*, **7**, *No.* 1, 48–50 (1955) In German.

The manometer consists of a conducting mica plate (1 cm^2 area and 6μ thick) attached to two platinized quartz fibres (7 cm long and 40μ thick) and suspended within a glass envelope close to plane electrodes connected to an electrical circuit which can maintain the suspended system in resonant oscillation. By placing an indirectly heated plate near to the mica

plate the manometer can be converted into a Knudsen type. Calibration curves for H_2 and Xe using a McLeod gauge are given and the vapour pressure/temperature curves of three organic substances, determined with the manometer, are shown as examples of the use of the instrument. S. WEINTROUB

MECHANICS OF FLUIDS 532

532.13

4402. The temperature-dependence of the viscosity of water between 0° and 40°C. W. WEBER. *Z. angew. Phys.*, **7**, *No.* 2, 96–8 (1955) In German.

A formula is proposed which is claimed to give better values than can be obtained by Kampmeyer's method [Abstr. 2450 (1952)]. T. C. TOYE

532.13 : 532.584

4403. The viscosity of suspensions of spheres. C. ORR, JR AND H. G. BLOCKER. *J. Colloid Sci.*, **10**, *No.* 1, 24–8 (*Feb.*, 1955).

Particle size distribution, often suggested as a factor influencing the viscosity of suspensions, is considered quantitatively. By an analysis of previously reported data, the viscosity of suspensions of spheres from the lowest to the highest concentration is shown to be described in terms of the viscosity of the pure liquid, the volume fraction of solids, the packed sediment volume of solids, and the geometric standard deviation for the solids. A.

532.13 : 532.72

4404. Self-diffusion coefficient and viscosity in liquids. J. C. M. LI AND P. CHANG. *J. chem. Phys.*, **23**, *No.* 3, 518–20 (*March*, 1955).

The relation between self-diffusion coefficient and viscosity is examined in terms of the early hydrodynamic theory and Eyring's kinetic theory. They differ by a factor of about 6. A detailed consideration of the kinetic theory shows that this factor should have been included in Eyring's derivation of viscosity if a proper meaning is given to the relative velocity involved. A.

532.13 : 541.64

4405. Treatment of viscosity data on polymer solutions (an analysis of equations and procedures). I. Intrinsic viscosity and limiting slope constants. W. HELLER. *J. Colloid Sci.*, **9**, *No.* 6, 547–73 (*Dec.*, 1954).

Existing equations and conventional procedures for the graphical determination of intrinsic viscosity and slope constants are analysed. It is shown that slope constants obtained by the conventional procedures contain a systematic error which varies with the intrinsic viscosity. Several new equations and procedures are proposed which allow a more precise and more accurate determination of intrinsic viscosity and slope constants. Accuracy and precision of the latter data are checked by means of relationships existing between the various quantities. Several new relationships between the various quantities are established and tested. Attention is drawn to the possible application of the new equations and procedures to the evaluation of measurements of osmotic pressure and of light scattering. A.

532.5 : 523.75

Magnetohydrodynamic waves under the action of the Coriolis force. *See Abstr.* 4304

532.5 : 523.877

The character of the instability of an incompressible fluid of constant kinematic viscosity and exponentially varying density. *See Abstr.* 4325

532.511

4406. The derivation of the equations of motion of an ideal fluid by Hamilton's principle. J. W. HERIVEL. *Proc. Cambridge Phil. Soc.*, **51**, *Pt* 2, 344–9 (*April*, 1955).

A new formulation of Hamilton's principle for the case of an ideal fluid is proposed which is claimed to be the uniquely proper form for such a system. The resulting derivation of the equations of motion on varying with respect to the position of the fluid particles is free from the difficulties encountered in previous treatments based on incorrect forms of Hamilton's principle. The treatment also differs from previous treatments in transforming to the fixed (a, b, c) space before carrying out the variation, and in allowing for the equations of mass and entropy conservation by means of undetermined multipliers. The necessity for conservation of entropy, if Hamilton's principle is to be applied, is emphasized. Finally, the method, first used by Eckart, of deriving the equations of motion for an ideal fluid by means of a variational principle of the same form as Hamilton's, but varying with respect to the velocities of the fluid particles, is extended to the general case of rotational motion. A.

532.517 : 534.39

Acoustic streaming in liquids. *See Abstr.* 4470–1

532.517.2

4407. On a property of Poiseuille flow. T. SEXL. *Acta phys. Austriaca*, **9**, *No.* 1, 75–6 (1954) In German.

A short note on energy dissipation in streamline flow through a circular pipe. T. C. TOYE

532.517.4

4408. A theory of turbulence. S. CHANDRASEKHAR. *Proc. Roy. Soc. A*, **229**, 1–19 (*April* 5, 1955).

An attempt is made to develop a deductive physical theory of turbulence. The basic idea in this theory is the introduction of correlations in the velocity components (u_i) at two different points ($\mathbf{r}'$ and $\mathbf{r}''$ say) and at two different times (t' and t'' say). It is assumed that in stationary, homogeneous and isotropic turbulence these correlations depend, apart from the vector joining the points $\mathbf{r}'$ and $\mathbf{r}''$ only on $|t' - t''|$. With one additional statistical hypothesis that the fourth-order moments,

$$Q_{ij;kl} = \overline{u_i(\mathbf{r}', t')u_j(\mathbf{r}', t')u_k(\mathbf{r}'', t'')u_l(\mathbf{r}'', t'')},$$

are related to the second-order moments, $Q_{ij} = \overline{u_i(\mathbf{r}', t')u_j(\mathbf{r}'', t'')}$ as in a joint normal distribution, a non-linear partial differential equation is derived for the defining scalar, $Q(r, t)(r = |\mathbf{r}' - \mathbf{r}''|$ and $t = |t' - t''|)$ of Q_{ij}. This differential equation gives precision to the idea that in some sense, the inertial and the viscous terms in the equations of motion act alike with effects which are additive. In the limiting case of infinite Reynolds number the equation for Q is discussed in some detail. It is shown how the theory

enables one to follow explicitly the initial evolution of Q, if at $t = 0$, it has the form one supposes on Kolmogoroff's similarity principles. For $t \to \infty$, it appears that the solution is separable in the variables r and t; the nature of these solutions (which form a one-parameter family) are discussed and illustrated. A.

CAPILLARITY 532.6

532.6 : 536.48 : 537.312.62

4409. Transfer of mass and charge by surface waves. A. A. Vlasov. *Zh. éksper. teor. Fiz.*, **27**, *No.* 2(8), 224–42 (1954) In Russian.

Out of two factors contributing, in van der Waals's theory of capillary state, to the surface-layer equilibrium, the kinetic pressure is insufficient at very low temperatures, and hence the intermolecular attraction can only be compensated by macroscopic surface motion of the liquid. This motion may be construed as waves, the theory of which, for heavy liquids, was recently treated by Nekrasov [*Akad. Nauk SSSR, Moscow* (1951)] and the author [*Theory of many bodies*, Gostekhizdat (1950); also Abstr. 461 (1949)]. The boundary problem of the theory of many bodies is shown to point to the existence of the transfer of matter by the surface waves. The results of mathematical treatment are applied to the concrete cases of: (1) capillary waves in He II, and (2) electric surface waves in the electronic plasma of superconductors. F. LACHMAN

532.612.3 : 539.42

4410. The weakening effect on paraffin and waxes with its application for determining their surface tensions in solid state. M. Sato. *Ark. Fys.*, **9**, *Paper* 19, 335–9 (1955).

The lowering of the breaking strength of paraffin, beeswax, and Japan wax brought about by wetting of the solids with methanol, ethanol, *n*-butyric acid, formic acid, spindle oil, glycerine and water was investigated. It was found to vary regularly with the surface tension of the wetting liquid. The surface tensions of the solids are assessed and found to be respectively 46·1, 45·1 and 59·6 dyne/cm. W. GOOD

MOLECULAR THEORY OF LIQUIDS 532.7

532.7

4411. The radial distribution function calculated by the Monte-Carlo method for a hard sphere fluid. B. J. Alder, S. P. Frankel and V. A. Lewinson. *J. chem. Phys.*, **23**, *No.* 3, 417–19 (*March*, 1955).

The radial distribution function of a fluid of rigid spheres has been calculated using I.B.M. equipment by a Monte Carlo method which is valid only at relatively low densities. Up to the highest densities studied, 20% of closest packing, the radial distribution function agrees within the precision of the method with the one calculated by the use of the superposition approximation in triplet space. Another Monte Carlo approach was used at a higher density, 72·4% of closest packing, and the results agree with published computations. A.

532.72 : 778.34

4412. On the diffusion of sodium uranylcarbonate in nuclear photographic plates. R. Desprez and M. Morand. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 4, 417–19 (*Jan.* 24, 1955) In French.

Describes an experimental technique for studying the diffusion of α-tracer ions in aqueous solution, in thick layers of nuclear emulsion. P. ROTHWELL

532.72

4413. A direct interchange mechanism in liquid tin and indium self diffusion. G. Careri and A. Paoletti. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 3, 517–18 (*March*, 1955).

Experiments show that the self-diffusion in these liquids does not follow the usual logarithmic dependence on $1/T$; the plots show a curvature well outside experimental error. An expression for the diffusion is derived on the assumption that a ring or direct interchange is involved, and the data can be fitted closely with values of the parameters which agree well with similar quantities in solids. This is taken to indicate a quasicrystalline nature of the liquid phase. W. M. LOMER

532.72

4414. Mutual viscosity and diffusion in liquid mixtures. N. E. Hill. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 4, 209–12 (*April*, 1955).

A theory of diffusion in liquid mixtures is proposed which shows that the intrinsic diffusion coefficient, $\mathscr{D}_A$, of the substance A in a mixture of A and B in which the mole fractions are respectively f_A and f_B is $\mathscr{D}_A = kT/6(f_A\eta_A\sigma_A + f_B\eta_{AB}\sigma_{AB})$ where η_A is the viscosity of the pure liquid A, η_{AB} is the mutual viscosity of the mixture, and σ_A and σ_{AB} are intermolecular distances. This leads to values of D, the measured diffusion coefficient, which are in good agreement with the experimental values, both in the limiting case when the concentration of one component is very low, and for 50% mixtures. A.

532.72

4415. Measurement of mass transfer by an electrical conductivity method. E. W. Gaylord and W. Forstall. *Brit. J. appl. Phys.*, **6**, *No.* 4, 135–8 (*April*, 1955).

A method has been developed to study the diffusion of fresh water into salt water using electrical conductivity cells in such a manner that it is possible to determine continuously, rapidly, and inexpensively what portion of any sample of the mixture came from the salt water, and what portion came from the fresh water. The method is one of comparison; an exact determination of the salt concentration of the salt water before mixing is not required. The method is restricted to the study of incompressible flow problems and subject to the limitations imposed by the use of water. A.

532.73 : 536.7

4416. Remarks on the thermodynamics of solutions of gases and solids in liquids. H. Mauser and G. Kortüm. *Z. Naturforsch.*, **10a**, *No.* 1, 42–7 (*Jan.*, 1955) In German.

Both the experimental and theoretical thermo-

dynamic treatment of solutes is simplified by taking as the reference state instead of an "ideal" state, not realizable physically, the pure substance in equilibrium with the saturated solution. This adoption also makes it possible to get a second approximation for the chemical potential of a solute, provided that its solubility is known and also the ideal solubility. Approximate values are calculated for the distribution of iodine between water and carbon disulphide, and are compared with experimental measurements.

R. C. MURRAY

532.73 : 536.7

4417. Molecular formulation of thermodynamic functions encountered in solution theory. F. P. BUFF AND R. BROUT. *J. chem. Phys.*, **23**, *No.* 3, 458–65 (*March*, 1955).

The general statistical mechanical formulation of partial molar energies, "internal pressure" and heat capacity of multicomponent systems is developed with use of the grand ensemble. In the case of two component systems, detailed concentration expansions are presented for partial molar free energies and energies and for radial distribution functions about standard states at constant temperature and pressure as well as constant temperature and partial molar volume. A.

532.73 : 536.7

4418. The statistical thermodynamics of solutions of non-spherical molecules. I. The thermodynamic functions. J. S. ROWLINSON AND J. R. SUTTON. *Proc. Roy. Soc. A*, **229**, 271–80 (*April* 21, 1955).

The perturbation treatment of the orientational forces between non-spherical molecules proposed by Cook and Rowlinson [Abstr. 7646 (1953)] is extended to mixtures by using the theory of solutions put forward by Longuet-Higgins [Abstr. 2427 (1951)]. The thermodynamic functions and the equation of state of such mixtures are expressed in terms of the intermolecular forces and the properties of one pure component. Expressions are derived for the excess (or non-ideal) thermodynamic functions which are compared with the experimental results on the four solutions, benzene + cyclohexane, benzene + carbon tetrachloride, benzene + ethylene dichloride, and cyclohexane + carbon tetrachloride. The agreement between theory and experiment is improved by taking account of the orientational forces. A.

532.74

4419. Complex formation between silver ions and thiocyanate ions in aqueous solutions. I. LEDEN AND R. NILSSON. *Z. Naturforsch.*, **10a**, *No.* 1, 67–76 (*Jan.*, 1955) In German.

The nature and stability of silver thiocyanate complexes were investigated in aqueous solutions over a large range of concentrations. The solubilities of AgCNS and $NaAg(CNS)_2(H_2O)_2$ in NaCNS solutions, of which the ionic concentrations were stabilized by the addition of $NaClO_4$, were studied. Some potentiometric experiments were carried out on unsaturated AgCNS solutions with fairly high concentrations of NaCNS. The presence of mononuclear complexes $Ag(CNS)_n^{1-n}$ with $n = 1$, 2, 3 or 4 was confirmed. Polynuclear complex ions are probably of the form $Ag_m(CNS)_{2m+2}^{-(m+2)}$ where m can be any whole number, including large values. Relations describing the reactions which take place are derived and the reaction equations given. Solubility constants are tabulated. A. J. TAYLOR

532.74 : 534.32

Brown University conference on acoustics and the structure of liquids (June 1954). *See Abstr.* 4457

532.74 : 539.152.2

4420. Determination of the proton spin-lattice relaxation time of liquids by a streaming method. A. GANSSEN. *Z. Naturforsch.*, **10a**, *No.* 1, 54–61 (*Jan.*, 1955) In German.

With rates of >50 cm/sec of sample liquid flow through a Bloch nuclear induction system the signal disappears, as the spin-lattice relaxation time, T_1, is too long for the establishment of thermal equilibrium in the magnetic field. If the flow is suddenly stopped the signal reappears at a rate dependent on T_1 which can be measured. Values obtained include: H_2O, 2·35 sec; 10^{-5} M $MnSO_4$, 0·5 sec; $(C_2H_5)_2O$, 3·9 sec; benzene, 3·1 sec; CH_3OH, 3·2 sec at room temperature. D. H. WHIFFEN

532.77

4421. Some remarks on the theory of the Maxwell effect of solutions of macromolecules. R. CERF. *J. Chim. phys.*, **52**, *No.* 1, 53–9 (*Jan.*, 1955) In French.

A more detailed discussion of relations given earlier [Abstr. 652, 2250 (1953)]. By considering the elastic deformation of a spherical particle, it is shown that the limiting value of the ratio: (angle between flow direction and neutral axis)/(velocity gradient), equals half the time of relaxation of deformation. Rigid ellipsoidal and permeable particles are also considered. G. F. LOTHIAN

532.77

4422. On the thermodynamics of dilute solutions. Case of two components and one phase at constant temperature and pressure. K. POPOFF. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 7, 735–7 (*Feb.* 14, 1955) In French.

The application of relations previously established [Abstr. 4481 (1954), 1787 (1955)] to the dissociation of acetic acid in aqueous solution is considered.

F. E. HOARE

532.77 : 535.343

Absorption spectra of metals in solution. *See Abstr.* 4532

532.783

4423. Electrical-optical effects in liquid crystalline solutions containing amphiphilic salts. P. A. WINSOR. *J. Colloid Sci.*, **10**, *No.* 1, 101–6 (*Feb.*, 1955).

Electrical-optical effects are described which are shown specifically by liquid crystalline solutions of colloidal electrolytes. Theoretical speculations are advanced concerning the origins of the observed effects. See also Abstr. 3180 (1954). A.

MECHANICS OF GASES 533

533.15 : 539.152.2

4424. Performance of hot wire thermal diffusion columns. R. C. SRIVASTAVA. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 294–6 (*April*, 1955).

Furry and Jones's theory [Abstr. 2147 (1946)] of the

thermal diffusion column for the extreme cylindrical case has been extended to take into account the temperature variation of the thermal diffusion constant α with temperature in the usual form $\alpha = A - B'/T$. The expressions so obtained for the column constant H are shown to agree closely with the experimental data of Simon on argon. A.

533.21

4425. The compressibility of gases. I. The Burnett method. An improved method of treatment of the data. Extension of the method to gas mixtures. W. C. Pfefferle, Jr, J. A. Goff and J. G. Miller. *J. chem. Phys.*, **23**, *No.* 3, 509–13 (*March*, 1955).

The theory of the Burnett method of measuring the compressibility of gases is discussed, and an analytical method of treating the data is presented. Determinations of the compressibility factor at 30°C for helium, nitrogen, and carbon dioxide show the convenience of the analysis and the precision that may be obtained by the method. Extension of the Burnett measurement to gas mixtures is also reported for some binary combinations of the three gases. A.

533.21 : 536.7

4426. Compressibilities of ozone, oxygen, and ozone-oxygen mixtures and the thermodynamic quantities for pure ozone. C. M. Birdsall, A. C. Jenkins, F. S. DiPaolo, J. A. Beattie and C. M. Apt. *J. chem. Phys.*, **23**, *No.* 3, 441–52 (*March*, 1955).

The compressibilities of ozone and ozone-oxygen mixtures were calculated from recently determined critical constants for pure ozone, and from well-established data for oxygen. Data for pure ozone, pure oxygen, and mixtures containing 20, 40, 60 and 80 mole per cent ozone are presented. The calculated compressibilities of pure ozone are used to correct thermodynamic quantities for the ideal gas, computed from spectroscopic data, to real gas conditions. Experimental determination of the compressibilities would be difficult because of the unstable nature of ozone. A.

533.59

4427. A hydrogen Pirani leak detector using a charcoal trap. T. B. Kent. *J. sci. Instrum.*, **32**, *No.* 4, 132–4 (*April*, 1955).

A simple robust dynamic leak detector suitable for vacuum proving large numbers of components down to $10^{-3}1\mu$/sec is described. The property of charcoal at low temperatures to absorb a large percentage of atmospheric gases and little hydrogen is used to eliminate irregular pressure pulses caused by impurities in the component and to increase the response of a Pirani gauge when a leak is probed with hydrogen. A charcoal trap is placed between the component and a Pirani gauge on a vacuum unit. A.

533.6.011.3

4428. Flow of gas at high subsonic speeds through short pipes, in a pressure range between 10^{-2} and 10 torr. K. G. Günther, R. Jaeckel and G. W. Oetjen. *Z. angew. Phys.*, **7**, *No.* 2, 71–7 (1955) In German.

The flow of air and superheated steam in quantities from 1 to 2000 g/hr through tubes of 3 to 80 cm length and 1·5 to 7 cm diameter was investigated for subsonic speeds in a pressure range between 10^{-2} and 10 cm Hg. The apparatus used, the flow characteristics and the measurement of pressure and of flow rate are described. A mathematical treatment of the problem is given. G. Wittenberg

533.6.011.3

4429. Entrainment and turbulence in open gas streams. R. H. Gough. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 4, 234–40 (*April*, 1955).

A method of studying the entrainment of air by a moving gas stream is presented which consists, in effect, of constructing entrainment curves for specified positions within the stream. Curves such as these have not, so far as is known, been published previously. They are of interest in showing the change from laminar to turbulent flow in the stream with particular clarity. A comparison with entrainment curves for gas burners is made. The profile of the gas flow in the region of the laminar-turbulent transition region has also been studied experimentally, and a correlation obtained with the previous results. A.

533.6.011.4

4430. Acceleration of slender bodies of revolution through sonic velocity. J. D. Cole. *J. appl. Phys.*, **26**, *No.* 3, 322–7 (*March*, 1955).

The linearized theory of slender bodies in arbitrary motion at zero angle of attack has been worked out. The results have been applied to a smooth body accelerating uniformly through sonic velocity. The theory can be used to estimate the non-linear or transonic effects. For an accelerating body, the parameter $(bl/c^2)^{\frac{1}{2}}$ is important where $2b$ = acceleration, $2l$ = length of body, c = sound speed at infinity. For sufficiently high $(bl/c^2)^{\frac{1}{2}}$, transonic effects can be neglected. Using linearized theory to estimate the ratio of non-linear terms in the differential equation gives

$$\lambda = \frac{\text{non-linear terms}}{\text{significant linear terms}} = \frac{3}{4}(\gamma+1)\frac{\delta^2}{(bl/c^2)^{\frac{1}{2}}}\left[\log\frac{2}{\delta^2}\left(\frac{c^2}{bl}\right)^{\frac{1}{2}} - \frac{9}{4}\right],$$

where δ = thickness ratio of body. The result above is evaluated at the maximum thickness of a symmetric parabolic arc body at the instant it passes through sonic velocity. For $\lambda < 1$ transonic effects can be neglected while for $\lambda > 1$ they begin to dominate. For practical applications the result shows that there is a possibility of a sufficiently long and slender missile accelerating fast enough to avoid transonic effects (e.g. 50 ft long, 5% thick, $3g$ acceleration). For conventional aircraft, transonic effects will dominate. An interesting side result is that when the acceleration is sufficiently large so that transonic effects do not matter the drag coefficient near sonic speed is independent of the acceleration ($C_D = 3\delta^2$ for parabolic arc body). A.

533.6.011.5 : 534.222.2

4431. Supplementary note to my paper "An approximate study of the detached shock wave in front of a circular cylinder and a sphere." K. Hida. Note in *J. Phys. Soc. Japan*, **10**, *No.* 1, 79–81 (*Jan.*, 1955).

An alternative solution of the problem discussed previously by the author [Abstr. 3187 (1954)] in which a stream function of an incompressible fluid was used in the analysis, is now given in terms of

Crocco's stream function [*Zeitschrift für angewandte Mathematik und Mechanik*, **17**, 1 (1937)] which, it is considered, clarifies the analysis, and provides an improved solution for the circular cylinder.

J. S. G. THOMAS

533.6.08

4432. Modifications in the omnidirectional ionization anemometer. W. L. WELMAN. Note in *J. sci. Instrum.*, **32**, *No.* 3, 119–20 (*March*, 1955).

Owing to the highly toxic character of polonium, the ionizing electrode, consisting of a sphere plated with polonium, used in the anemometer described by Lovelock and Wasilewska [Abstr. 791 (1950)] is replaced by one made by covering a half-inch ball-bearing with radium-gold foil, and the radius of the three concentric rings constituting the collecting electrode is increased from 8 to 10 inches, and 3 stubs are added; the collecting electrode is now enclosed within a wire-mesh sphere of diameter 15 cm.

J. S. G. THOMAS

533.6.08

4433. A thermocouple anemometer. R. F. BENSEMAN AND H. R. HART. *J. sci. Instrum.*, **32**, *No.* 4, 145–7 (*April*, 1955).

A simple anemometer for measuring airspeeds from below 0·01 ft/sec and up to any desired value is described. It can be used over a wide range of temperature and for remote indication with either a recorder or moving coil meter. In addition, the instrument can be adapted to measure airflows down to less than 0·0005 ft^3/min. The instrument is reasonably robust, can be safely cleaned and its calibration should remain constant indefinitely. A.

MOLECULAR THEORY OF GASES 533.7

533.7

4434. Metastable states of a finite lattice gas. A. J. F. SIEGERT. *Phys. Rev.*, **97**, *No.* 6, 1456–62 (*March* 15, 1955).

Some recent papers on condensation were based in part on the conjecture that the probability function $W(N_1)$ for the number of particles N_1 in a finite volume at given temperature and chemical potential μ per particle has two maxima for a finite range of these variables. The validity of this conjecture has been investigated for a finite version (square of N sites with toroidal connection) of the two-dimensional lattice gas of Lee and Yang. Considering at first only the values $N_1 \leqslant 3$ and $N_1 \geqslant N-3$, it is shown that $W(N_1)$ has at least two maxima for values of μ in the neighbourhood of the transition value at temperatures smaller than or approximately equal to $3{\cdot}5\,T_c/\ln N$ where T_c is the critical temperature of the infinite model, while the upper points of the first three saltus of the most probable density of the finite model approximate the density of the infinite model in the gas region with a relative error of order $N^{-\frac{1}{2}}$. (An analogous result holds by symmetry for the liquid region.) To extend these results to a larger range of numbers N_1 the authors consider a histogram obtained from $W(N_1)$ by summation over relatively narrow groups of numbers in the range $N_1 \leqslant n$, where n is an arbitrary integer $< N^{\frac{1}{2}}$. It is shown that at sufficiently low temperatures this histogram has a maximum centred on $N\rho_n$ where ρ_n is the nth partial sum of the Mayer series for the density of the infinite model in powers of the fugacity. The finite model thus provides a physical interpretation for the extrapolation of the density (by means of a partial sum of the Mayer series) beyond the transition value of the fugacity. A.

533.7 : 536.7

4435. On the calculation of thermal transpiration. S. CHU LIANG. *Canad. J. Chem.*, **33**, *No.* 2, 279–85 (*Feb.*, 1955).

The equation proposed earlier has been derived from a new kinetic concept. It is shown to be a reasonable approximation of this new consideration. The equation is also shown to be mathematically consistent with the general fact that when the thermomolecular pressure difference is plotted against the normally measured pressure, a single maximum is obtained. The curves calculated from this equation are shown to agree closely with those from the Weber equation using van Itterbeek and de Grande's data. The practical use of the equation is discussed. A.

VIBRATIONS . ACOUSTICS 534

534

4436. Acoustics and basic physics. P. M. MORSE. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 213–16 (*March*, 1955).

534.121.1

4437. The response of an elastic plate to localized driving forces. R. H. LYON. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 259–65 (*March*, 1955).

The vibration of an infinite elastic plate when driven by a localized driving force is studied theoretically. The dilation and shear potentials are expressed as Fourier integrals, the boundary conditions are applied, and the integrals evaluated by the calculus of residues. It is found that the motion of the plate may be represented by a discrete sum of non-orthogonal eigenmodes. These modes represent two types of waves, propagated and attenuated. The former are obtained from previous work on coincidence transmission. The latter are calculated by a graphical method, and presented in such a manner that they tie in continuously with the propagated modes. Certain unresolved features of the problem are discussed. One previous application of the theoretical results is disclosed. A.

534.121.1

4438. Fundamental frequencies of clamped triangular plates. H. L. COX AND B. KLEIN. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 266–8 (*March*, 1955).

Approximate solutions are given for the fundamental frequencies of flexural vibration of flat triangular plates with all edges clamped. The plate equation is written in skew co-ordinates and the method of collocation is used to obtain the approximate solutions. Results are presented in simple graphical form so that one may determine rapidly a desired fundamental frequency. A.

534.13

4439. The study of torsional vibration of EDT. P. JAVORSKÝ AND E. KLIER. *Czech. J. Phys.*, **4**, *No.* 3, 316–36 (*Sept.*, 1954) In Russian, Summary (2 *pp.*) in English.

A set of bars 3 cm long was used. The bars were ground to 2·6 cm long and cross-section 0·694 × 0·544. Other specimens were used with varying dimensions, and the formula for frequency of oscillation was tested for various orientations, and the effects of changes of dimension on frequency, nodal lines, and vibrational amplitude were observed. Various forms of electrode were used and frequencies of the torsional and flexural modes were measured. A marked coupling between the torsional and flexural modes was observed and agreed well with a theory of Voigt (1928). C. A. HOGARTH

534.131

4440. Some effects of the distribution of added mass to vibrating beams. H. COHEN AND G. HANDELMAN. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 1, 177 (*Jan.*, 1955).

The effect produced on the eigenfrequencies of vibrating beams by the addition of mass in such a manner that a portion of the beam is rigidified, is investigated. A.

534.133

4441. On the frequency constants of circular X-cut quartz crystals. B. ÖZDOĞAN. *Rev. Fac. Sci. Univ. Istanbul C*, **19**, *No.* 3, 193–9 (*July*, 1954).

Experimental observations on the variation of the frequency constant for different geometries and on the frequency spectrum observed about the longitudinal thickness mode. W. BARDSLEY

534.133 : 537.228.1 : 621.372.412

Piezoelectric quartz vibrators. *See Abstr.* 4632–4

534.154

4442. Electromagnetic sonometer. A. TURNER. *Amer. J. Phys.*, **23**, *No.* 3, 158–60 (*March*, 1955).

Application of an electromagnetic sonometer to the vibrating string experiment makes practicable an important experiment which has hitherto been difficult to perform. This sonometer makes it possible to demonstrate both sound and electrical experiments with very reliable results. A.

534.21

4443. Note on the propagation of normal modes in inhomogeneous media. I. TOLSTOY. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 274–7 (*March*, 1955).

Given a wave duct with continuously variable parameters extending from $y = 0$ to $y = H$, the reflection coefficients for originally plane down-going and up-going waves are written in the form $\Re\downarrow = -\exp(2i\chi\downarrow)$ and $\Re\uparrow = -\exp(2i\chi\uparrow)$, respectively. It is then shown that the characteristic equation governing the dispersion of undamped normal modes in the medium is $\chi\downarrow + \chi\uparrow = m\pi$, m being an integer defining the mode number. $\chi\downarrow$ and $\chi\uparrow$ are solutions of non-linear first-order differential equations. If the medium consists of n homogeneous layers of finite thickness, the differential equation is replaced by a recursion relation, and the characteristic equation shown above includes one additional term. A.

534.21

4444. Equivalent circuit of "Floating Lever" by the EFP analogy. B. B. BAUER. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 376 (*March*, 1955).

Reference is made to an earlier paper by the author [Abstr. 152 (1954)] in which he described a method for synthesizing the equivalent circuit of mechanical networks by the classical voltage-force-pressure (EFP) analogy. The purpose of the present note is to show an equivalent circuit representation of a "floating lever," using the EFP analogy—a floating lever being distinguished from an ordinary lever in that it does not have a stationary pivot.

A. B. WOOD

534.213

4445. Pipes and resonators. Calculation and measurement of some acoustic resistances. J. GUITTARD. *Acustica*, **5**, *No.* 1, 7–18 (1955) In French.

Calculations of the conductivity of holes, slits, etc. can be made under certain hypotheses in many cases. Expressions for the velocity potentials are necessary. Experimental results agree with theory, at any rate at the low frequencies used (100 . . . 500 c/s) but the precision is not great. The principal reason for this is to be found in the imperfections of classical theories on vibratory motions, which do not, in particular, take account of acoustic streaming or of the viscosity of the air. A.

534.213

4446. The propagation of sound impulses in metal cylinders. W. GÜTH. *Acustica*, **5**, *No.* 1, 35–43 (1955) In German.

By means of the integration method of "stationary phase" a theory of the propagation of impulses and similar sounds in a dispersive medium is developed and demonstrated on a circular metal cylinder. The theory is compared with experimental data obtained by schlieren methods. The possible use of these results to explain the formation of ripples on steel rails is discussed. A.

534.22/.23 : 537.226.2

4447. Permittivity and mechanical loss in long-chain polymers. H. THURN. *Z. angew. Phys.*, **7**, *No.* 1, 44–7 (1955) In German.

Electrical and ultrasonic measurements at equal frequencies in the temp. range −150 to +150°C show that sudden changes in permittivity with increasing temp. coincide with max. absorption and marked decrease in velocity of the ultrasonic waves.

J. H. MASON

534.22

4448. Elastic wave velocities in laminated media. J. E. WHITE AND F. A. ANGONA. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 310–17 (*March*, 1955).

The velocities of elastic waves in a laminated medium have been determined by calculating the effective elastic parameters and the effective density. The procedure is to assume the medium to be in static equilibrium and exposed to certain stresses. The stresses are of such a nature as to generate strains

similar to those which would exist during the passage of an elastic wave through the medium. From the application of Hooke's law, an effective stiffness constant for the medium is obtained. The ratio of this effective stiffness to the effective density is the square of the velocity of the elastic wave. For a medium consisting of layers of two materials with the same density but with a velocity contrast of two (2), the velocity of compressional waves travelling parallel to the layering is 20% higher than the velocity of the same wave travelling perpendicular to the layers. The SH shear wave has a velocity which is 25% higher than the SV shear wave for the same laminated medium. A.

534.22

4449. Ultrasonic dispersion in 1,1 and 1,2 dichloroethane vapors. T. Seshagiri Rao and J. C. Hubbard. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 321–5 (*March*, 1955).

The ultrasonic resonator interferometer has been used to measure the ultrasonic velocity at 30°c in 1, 1 dichloroethane (ethylidene chloride, CH_3CHCl_2) and 1, 2 dichloroethane (ethylene chloride, CH_2Cl-CH_2Cl) vapours as a function of frequency over pressure. The ranges of f/p employed are 0·8 to 100 Mc/s atmos^{-1} in the case of ethylidene chloride and 1·0 to 100 Mc/s atmos^{-1} in the case of ethylene chloride. The velocities have been corrected for non-ideality of the two vapours. Dispersion of ultrasonic velocity occurs in both the cases and this is ascribed to the slow rate of energy exchange between translational and vibrational states. There is evidence of double relaxation in the two cases, the principal $/fp$ ratios at 30°c being 76·5 Mc/s atmos^{-1} for the former and 102 Mc/s atmos^{-1} for the latter. A.

534.22 : 532.122

4450. Ultrasonic velocity and adiabatic compressibility in mixtures of alcohols with ethylene glycol. F. Danusso. *R.C. Accad. Naz. Lincei*, **17**, *No.* 5, 234–9 (*Nov.*, 1954) In Italian.

Previous work [Abstr. 3507 (1955)] is continued using ethylene glycol as the common component of binary mixtures of alcohols. The percentage deviations Δu, ΔV, ΔB of the ultrasonic velocity u, compressibility B, and molecular volume V, are tabulated and graphed. Volume contractions prevail, increasing with increasing concentration of hydrogen bonds, i.e. with decreasing molecular weight, of the variable component alcohol. Positive Δu and negative ΔB accompany negative ΔV. For homologous primary aliphatic alcohols the deviations decrease with increasing molecular weight until for octylic and heavier alcohols a partial sign change occurs, indicating partial immiscibility. Similar deviations occur, increasing respectively for branched, secondary and tertiary alcohols. For hydrocarbon mixtures [Abstr. 3506 (1955)] the deviation maxima of a given system occur at the same concentration. This is not always so for alcohols; suggesting, besides structural differences, that u is sensitive to structural factors to which V is not, and vice versa. J. J. PHIPPS

534.22 : 532.73

4451. Ultrasonic velocities in cadmium and zinc halides. C. G. Balachandran. *J. Indian Inst. Sci. A*, **37**, *No.* 1, 27–9 (*Jan.*, 1955).

Ultrasonic velocities and their variation with concentration at different temperatures, viz. 25°c, 40°c, 50°c and 60°c have been measured for solutions of cadmium chloride, cadmium bromide, cadmium iodide and zinc iodide. From the values of the velocities, the partial molal compressibilities have been calculated. The effect of associated ions on the partial molal compressibility indicates a deviation from the conclusions based on the Debye–Huckel theory for the three cadmium halides in the concentration range studied. On the other hand solutions of zinc iodide are found to obey the theory up to a concentration of 0·5N. A.

534.222.2

4452. Precision measurement of detonation and strong shock velocity in gases. H. T. Knight and R. E. Duff. *Rev. sci. Instrum.*, **26**, *No.* 3, 257–60 (*March*, 1955).

A simple system is described for determining the velocity of detonation or strong shock waves, with temperatures above 3 000°K, by using the conductivity behind the wave. Wave contact is made by two 0·036 in. wires set 0·1 in. apart in a Teflon plug mounted in the experimental tube. When a wave passes, signals are produced across a 30 K resistor in series with these wires and a 0·001 μf capacitor charged to 300 V. Any number of circuits may be paralleled across a single signal resistor if a diode is added to each circuit to prevent signal deterioration. The arrival time of a wave at a pin can be determined with an accuracy of almost 10^{-8} sec from an oscilloscope record of the signals. The principal advantages of this system are excellent space resolution and very simple basic circuitry. An amplifier is described which can be used with an individual pin circuit to fire a thyratron and extend the range of applicability of this system to waves with temperatures as low as 1 000°K. A.

534.23 : 539.11

4453. Ultrasonic attenuation in metals by electron relaxation. R. W. Morse. Letter in *Phys. Rev.*, **97**, *No.* 6, 1716–17 (*March* 15, 1955).

The recently observed temperature variation of ultrasonic attenuation in lead [Abstr. 969 (1955)] is interpreted as due to relaxation of the electron distribution. Using the same relaxation time as is involved in electrical conductivity good agreement with experiment is obtained. D. SHOENBERG

534.23

4454. Concerning the article by A. Bergassoli, F. Canac and T. Vogel, "The transmission of sound by spherical shells." M. C. Junger and P. W. Smith, Jr. Letter in *Acustica*, **5**, *No.* 1, 47–8 (1955).

See Abstr. 10901 (1954).

534.23

4455. Damping of ultrasonics in liquids. S. Parthasarathy, C. B. Tipnis and M. Pancholy. *Z. Phys.*, **140**, *No.* 2, 156–9 (1955) In German.

A variation of the light diffraction methods yields quick and accurate values of the absorption coefficient. Results are compared with earlier methods for a number of liquids. T. C. TOYE

534.23

4456. Ultrasonic attenuation studies in biased $BaTiO_3$ ceramics. T. F. Hueter and D. P. Neuhaus. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 292–6 (*March*, 1955).

The attenuation of pulsed 10 Mc/s ultrasound in barium titanate ceramics is studied as a function of temperature and applied field. In the region of the coercive field strength attenuation maxima are observed which correlate with a rapid change of the electromechanical response. Both phenomena can be traced to domain wall movements of two different kinds. A model is proposed which identifies one kind of attenuation maximum with a stress equalization in the polarized crystal grains of a ceramic, and the other kind with the nucleation of antiparallel domains. In both cases the losses appear to be caused by an elastic hysteresis due to dislocation movement. A.

534.23 : 532.74

4457. Brown University conference on acoustics and the structure of liquids (June 1954). R. B. Lindsay. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 1, 173–4 (*Jan.*, 1955).

534.23 : 532.7

4458. Importance of different experimental conditions in the action of ultrasound. A. Dognon and Y. Simonot. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 6, 608–10 (*Feb.* 7, 1955) In French.

Experimental conditions such as the nature of surface, height of vibrating liquid and the effect of the walls of the containing vessel are examined as possible causes of disagreement between various observers. T. C. Toye

534.23 : 532.7

4459. Influence of the form and nature of the vessels used in the action of ultrasound. A. Dognon and Y. Simonot. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 7, 737–9 (*Feb.* 14, 1955) In French.

Supplementary to paper described in preceding abstract.

534.232

4460. The four-pole equivalent circuits of electromechanical transducers. W. Reichardt and A. Lenk. *Acustica*, **5**, *No.* 1, 1–6 (1955) In German.

The two possible circuits are developed for simple electrostatic, electromagnetic, and electrodynamic transducers, utilizing in each case two particularly simple electromechanical coupling networks. Their practical applications are compared. Magnetostrictive and piezoelectric transducers will be discussed in Pt II. A.

534.232

4461. Transducer design for ultrasonic delay lines. H. J. McSkimin. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 302–9 (*March*, 1955).

The problem of obtaining low-loss ultrasonic delay lines for switching, computer, and certain radar applications is discussed. An analysis is made of structures using half-length and quarter-wavelength bonds between the transducer and the acoustic medium to widen the pass-band; results are listed for both quartz crystal and barium titanate transducers. For barium titanate transducers (80% $BaTiO_3$, 12% $PbTiO_3$, 8% $CaTiO_3$), it is shown that a theoretical flat bandwidth of approximately 30% with less than 1 db midband loss can be obtained with a bond of negligible thickness. This bandwidth can be increased to approximately 46% without additional loss if a properly designed bond is used (i.e. $\frac{1}{4}\lambda$ bond for radiating into water, $\frac{1}{2}\lambda$ for used with a fused silica delay medium). A 70% bandwidth can be obtained with only 4 db loss per transducer. Confirming experimental results are described for delay lines using quartz crystals and one-half wavelength plastic seals or one-quarter wavelength solder seals. For the latter, bandwidths of 85% of mid-band frequency have been obtained. An efficient delay line using $BaTiO_3$ transducers is also described. A.

534.232

4462. Production of spray by high power magnetostriction transducers. A. E. Crawford. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 1, 176–7 (*Jan.*, 1955).

Produced by a window-type stack transducer in the frequency range 15 to 30 kc/s, the spray differs from the fog produced by higher frequency crystal transducers. W. Bardsley

534.26

4463. Underwater ultrasonic scattering by a radial cylindrical temperature gradient. P. E. Grant. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 287–91 (*March*, 1955).

The scattering of a one-megacycle underwater ultrasonic beam by a radial cylindrical temperature gradient perpendicular to the beam is studied as a function of position and gradient strength. The gradient is produced by a vertical hot wire. The presence of free convection currents makes necessary a time average study of both the temperature and scattering distributions. From these studies average temperature and scattering distributions are constructed, and it is found that a possible diffractive transition region exists between temperature gradients of 14·5 and 26·5°c/cm. In addition, there is evidence that a transition from wave to ray acoustics occurs between gradients of 26·5 to 36·5°c/cm. A.

534.26 : 535.43 : 538.566

4464. The scattering of a scalar wave by a semi-infinite rod of circular cross section. D. S. Jones. *Phil. Trans A*, **247**, *No.* 934, 499–528 (1955).

The form of the exact solution for the scattering of a plane harmonic scalar wave by a semi-infinite circular cylindrical rod of diameter $2a$ is found when the boundary condition is $u = 0$ or $\partial u/\partial v = 0$, where u represents the scalar field and v is the normal to the rod. When the angle of incidence is π, i.e. the angle between the direction of propagation of the incident wave and the normal (out of the rod) to the end is π, the average pressure amplitude on the end of the rod and the scattering coefficient are found for the boundary condition $\partial u/\partial v = 0$. Graphs are given showing the behaviour of these quantities for the range $0 \leqslant ka \leqslant 10$, where k is the wave-number. When ka reaches 10, the quantities have almost become constant. For small values of ka the scattering coefficient is shown to be $\frac{1}{4}(ka)^2$; it appears from the numerical results that this is, in fact, a fairly close approximation for $ka < 2$. It is further shown that the average pressure amplitude on the end for other angles of incidence is approximately the product of

the average pressure amplitude for an angle of incidence of π and the amplitude of the symmetric mode ($ka < 3{\cdot}83$) which the incident field would produce inside a hollow semi-infinite cylinder occupying the same position as the rod. When the boundary condition is $u = 0$ and ka is small it is proved that the scattered field is the same as that due to a semi-infinite hollow cylinder longer by an amount $0{\cdot}1a$ approximately. A similar result does not hold for the boundary condition $\partial u/\partial v = 0$. The theory is extended to the case when a pressure pulse falls on a circular rod. It is found that the pressure on the end drops almost to its final value in the time taken for a wave to travel the diameter of the rod, and that the average pressure during this process is given, at time t, by $[0{\cdot}915 + 0{\cdot}745(2-a_0t/a)^2]^{\frac{1}{2}}$ approximately, where a_0 is the speed of sound. Tables, in the range $0(0{\cdot}25)10$ of ka, of the "split" functions which arise in connection with a semi-infinite cylinder are given. A.

534.26 : 538.566

Acoustic scattering from semi-infinite bodies of revolution. *See Abstr.* 4815–16

534.321.7

4465. Why an international standard tuning frequency. R. W. YOUNG. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 379–80 (*March*, 1955).

The author discusses the difficulties arising in tuning the various types of musical instruments comprising an orchestra, and the necessity for tuning to be standardized. Musicians play in more than one orchestra and some may play in a different town or even country each night. A detailed discussion is given of the complications arising in the tuning of a flute when it is based on A 440 c/s or A 435 c/s. Various proposals are made in an effort to obtain international standardization, e.g. (*a*) equal temperament should be adopted as a framework for comparison, (*b*) a tolerance of ± 4 cents be acceptable for the tuning of the central octaves of keyboard instruments, and (*c*) for wind instruments the accepted tolerance should be ± 10 cents. A. B. WOOD

534.321.9

4466. A method of transducing an ultrasonic shadowgraph or image for display on an oscilloscope. E. E. SUCKLING AND W. R. MACLEAN. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 297–301 (*March*, 1955).

It is found that the pattern of piezoelectric voltage on the surface of a resonant crystal corresponds to the pattern of the exciting ultrasonic field. A capacity scanning system is described whereby ultrasonic shadowgraphs and images are reproduced for observation in a manner similar to that used in television. A.

534.321.9 : 534.39 : 535.371 : 537.312.5

4467. The effect of ultrasound on the conductivity and fluorescence of zinc and cadmium sulphide crystals. L. HERFORTH AND J. KRUMBIEGEL. Note in *Naturwissenschaften*, **42**, *No.* 2, 39 (1955) In German.

Ultrasonic radiation causes the photoconductivity of excited ZnS and CdS crystals to fall to a constant value depending on the sound intensity (up to $0{\cdot}8$ W/cm^2). The effect is reversible. The fluorescence intensity in each case is unaffected even at the maximum sound intensity. G. F. J. GARLICK

534.39

4468. Studies on acoustic radiation pressure. I. General considerations. J. AWATANI. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 278–81 (*March*, 1955).

The equation derived by Kotani and King relating to the excess pressure valid to the second order in the acoustic field is examined. It is shown that the solution of the usual wave equation can be used in the case when the radiation pressure in the Langevin's sense is derived from this equation. The reason why not only the normal force but also the tangential force on the non-stiff surface result from the radiation pressure defined from the viewpoint of the pressure in hydrodynamics, is clarified by considering the motion of the surface. The general expression for the radiation pressure on a rigid object in motion due to inertia effect, is developed by introducing moving co-ordinates. A.

534.39

4469. Studies on acoustic radiation pressure. II. Radiation pressure on a circular disk. J. AWATANI. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 282–6 (*March*, 1955).

A general formula for the radiation pressure acting on a thin rigid circular disk is derived from the theory of Pt I. Motion of the disk under action of the wave and diffraction of the wave due to the disk are taken into account. Constants which may be calculated by the use of the oblate spheroidal functions necessary in obtaining the radiation pressure are given in a table. Numerical calculation for disks of various weight with the ratio of the circumference of the disk to the wavelength of sound up to $3{\cdot}5$ is carried out. A.

534.39 : 532.517

4470. A study of acoustic streaming in liquids over a wide frequency range. A. M. GHABRIAL AND E. G. RICHARDSON. *Acustica*, **5**, *No.* 1, 28–34 (1955).

An experimental study is made of the streaming in liquids from vibrating bodies from infrasonic to ultrasonic frequencies. It appears that the general form of the streams is the same at all frequencies and satisfies a formula due to Rayleigh. In certain liquids at higher frequencies there is additional streaming, which is related to radiation pressure and the high attenuation of the sound waves. Possible causes of this high attenuation are discussed. A.

534.39 : 532.517

4471. Acoustic streaming near a small obstacle. P. J. WESTERVELT. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 379 (*March*, 1955).

In an earlier paper [Abstr. 2066 (1954)] the writer derived an invariance theorem concerning the steady flow pattern generated by oscillatory flow in the vicinity of an obstacle. The flow engendered by a smooth object oscillating to and fro with a small amplitude in a viscous incompressible fluid was shown to be invariant with respect to the co-ordinate transformation which renders the object stationary. He now draws attention to a comment by F. C. Clauser that this theorem is an immediate consequence of the fact that the vorticity equation for incompressible flow is invariant with respect to the transformation under consideration and is valid without restrictions as to amplitude of the motion. A. B. WOOD

534.6 : 518.5

4472. An analog electronic correlator for acoustic measurements. K. W. Goff. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 223–36 (*March*, 1955).

A study has been made of the applicability of correlation techniques to the field of acoustic measurements. The development of an analogue electronic correlator for this study is reported here while the application of the correlation technique to some acoustic measurements is reported in the abstract following. The analogue correlator is divided into the following four main components and each one is discussed in detail: (1) variable time delay; (2) quarter-squaring multiplier; (3) continuous and stepping integrators; (4) system for scanning and plotting the cross-correlation function on both linear and logarithmic scales. The correlator operates over an input frequency range of 100 c/s to 10 kc/s, a range of relative time delay τ from -15 to 190 millisec and RC integration times of 0·5 to 16 sec. A dynamic range in the cross-correlation function of approximately 50 db is achieved with ± 1 db accuracy. Special attention has been given to the errors in the cross-correlation function resulting from finite integration time and scanning of the correlation function. A significant increase in permissible scanning speed for a given signal-to-noise ratio has been shown to result from "matching" the equivalent integrator pass band to that of the spectrum common to the two signals applied to the correlator. Relations have been derived between scanning speed, signal-to-noise ratio and input signal bandwidth for integration performed by either a low-pass filter or a "matched" filter. A.

534.6 : 518.5

4473. The application of correlation techniques to some acoustic measurements. K. W. Goff. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 236–46 (*March*, 1955).

Discusses the application of an analogue correlator which computes the cross-correlation function between two sound pressures to such measurement problems as the localization of noise sources, the determination of transmission loss, and the reduction of microphone wind noise. The cross-correlation function $\phi_{21}(\tau)$ between two non-periodic signals will have a peak in amplitude if a component of each signal originates from a common source. The value of time delay τ for which this peak occurs equals the difference in time required for the individual components to propagate from the common source to the two points under study. An analogue electronic correlator described in the preceding abstract has been constructed which, by employing this property of the cross-correlation function, can separate the acoustic signal at a given point into components according to: (1) their points of origin (assuming independent sources), (2) the transit time from source to the point in question, and (3) frequency. Preliminary experimental results show that correlation provides a practical method for determining the amount of sound contributed to the field at a given point by each of several sources. The correlator, by separating the signal transmitted directly through the structure from the flanking signal on the basis of arrival time, is also a useful tool for measuring the transmission loss of walls. A.

534.6 : 534.23

4474. Concerning the article by W. Kuhl, "Possible errors in transmission loss measurements at low frequencies. I." V. M. A. Peutz. Letter in *Acustica*, **5**, *No.* 1, 46–7 (1955).

See Abstr. 1636 (1955).

534.61

4475. An acoustic intensity meter. S. Baker. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 269–73 (*March*, 1955).

A device is described for measuring the intensity of an acoustic wave at a point. The instrument employs a crystal microphone as a pressure transducer, a directional hot-wire anemometer as a velocity transducer and an electronic multiplier and integrator. The intensity for any pressure or velocity waveform can be directly measured without having to assume any relationship between pressure and velocity. Several types of measurements have been made to indicate the present capabilities of the instrument. A.

534.7

Physiological acoustics. Hearing. *See also under* "Medical science. Human physiology." Decimal classification 612.85

534.78

4476. Calculations on a model of the vocal tract for vowel /i/(meat) and on the larynx. J. van den Berg. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 332–8 (*March*, 1955).

As a sequel to experiments on the transmission of the vocal cavities, calculations on a model of the vocal tract for the vowel /*i*/ (meat) are performed to determine the magnitude of the impedances along the vocal tract and the relative contribution of radiation, friction, and coupled vibrations of the cavity walls to the total damping. Calculations also are made to estimate the impedances of the different parts of the larynx. From these calculations the effects of the coupling of the vocal cavities upon the larynx can be understood. Finally an old singing pedagogical problem concerning the resonances in the head is discussed. A.

534.78 : 612.85

4477. An analysis of perceptual confusions among some English consonants. G. A. Miller and P. E. Nicely. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 338–52 (*March*, 1955).

Sixteen English consonants were spoken over voice communication systems with frequency distortion and with random masking noise. The listeners were forced to guess at every sound and a count was made of all the different errors that resulted when one sound was confused with another. With noise or low-pass filtering the confusions fall into consistent patterns, but with high-pass filtering the errors are scattered quite randomly. An articulatory analysis of these 16 consonants provides a system of five articulatory features or "dimensions" that serve to characterize and distinguish the different phonemes: voicing, nasality, affrication, duration and place of articulation. The data indicate that voicing and nasality are little affected and that place is severely affected by low-pass and noisy systems. The indications are that the perception of any one of these five features is relatively independent of the perception of the others, so that it is as if five separate, simple channels were involved rather than a single complex channel. A.

534.79

4478. The apparent reduction of loudness: a repeat experiment. S. S. STEVENS, M. S. ROGERS AND R. J. HERRNSTEIN. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 326–8 (*March*, 1955).

The experiment of Laird, Taylor and Wille (1932) showed that the reduction in the intensity of a sound required to produce half loudness is of the order of 20 db. Since this result is out of line with most other studies in this field, an attempt was made to repeat the experiment with a similar piece of apparatus (2-A audiometer). The first attempt to copy the procedure of Laird, Taylor and Wille gave results more like those usually obtained, namely, a required reduction for half loudness of the order of 10 db. A second experiment, involving the use of comparison tones placed as much as 40 db below the standard, gave results more like those of Laird, Taylor and Wille. The method they used appears to be over sensitive to the range and order of presentation of the comparison stimuli. A.

534.79

4479. On the halving and doubling of the loudness of white noise. E. C. POULTON AND S. S. STEVENS. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 329–31 (*March*, 1955).

The decibel changes required to halve and to double the apparent loudness of a white noise were determined at nine sound pressure levels by 36 subjects. The subjects adjusted the level of the noise by means of an improved control—a "sone potentiometer" whose angular turn is roughly proportional to the loudness produced. An attempt was also made to measure and control some of the biasing factors that affect loudness estimations. Results: the median decibel changes required to produce a 2 : 1 loudness ratio ranged from 6 to 10 db, approximately. A.

534.83 : 534.78

4480. Masking by a periodically interrupted noise. I. POLLACK. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 353–5 (*March*, 1955).

A scale of noise intermittency may be represented at one extreme by a continuous non-interrupted noise and, on the other extreme, by an interrupted noise with silent intervals between successive noise bursts. The differential characteristic for various conditions along this scale is the noise level in the interval between successive noise bursts (the inter-burst level). The effects of a wide range of periodically intermittent noise conditions upon the masked threshold of a tone and the intelligibility of speech were examined. The principal result of these tests is that the masked threshold associated with an intermittent noise can be closely described by two functions: (1) the masking produced by an interrupted noise with silent intervals between successive noise bursts, and (2) the masking produced by a continuous uninterrupted noise at the inter-burst level. A.

534.833

4481. Subjective evaluation of sound insulation, investigation using electrically built-up insulation curves. H.-J. RADEMACHER. *Acustica*, **5**, *No.* 1, 19–27 (1955) In German.

The subjective sound insulation afforded by structures is investigated by building up insulation curves with an electrical filter, to show how modifications of the frequency characteristic may affect the resulting insulation. It appears unnecessary to specify by more than one parameter the insulation afforded by common types of walls to the usual types of noise. In an investigation on the insulation of footfall noise, the effect of varying the level in octave stages is shown as well as the improvement afforded in this case by covering layers on hollow floors. A.

534.835

4482. Noise of centrifugal fans. L. L. BERANEK, G. W. KAMPERMAN AND C. H. ALLEN. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 217–19 (*March*, 1955).

Extensions of earlier studies [Abstr. 3069 (1953)] on ventilation system noise are reported. It is shown here that in properly engineered ventilation systems the over-all sound power level in decibels *re* 10^{-13} watt is related to the horsepower rating of the fan motor by the formula: $\mathrm{PWL} = 100 + 10 \log_{10}$ h.p. The octave frequency band spectrum slopes off with increasing frequency at the rate of 5 decibels per octave. The level in the first band is one decibel below the over-all level. Measured data on fourteen fans in actual installations yield a spread of about ± 4 db around these relations. A.

534.839

4483. An explosive noise source. W. J. GALLOWAY, B. G. WATTERS AND J. J. BARUCH. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 220–3 (*March*, 1955).

A 10-gauge blank shotgun shell, exploded in a small cannon, has been used as an impulse source in performing a variety of acoustical measurements. The source has a peak power of the order of 10 000 watts with good reproducibility. The frequency spectrum simulates that of a typical turbojet engine. Instrumentation has been developed to permit simple and rapid analyses of measurements made with this source. Typical applications are described, and results obtained with the impulse source are compared to results obtained with continuous sources. A.

534.843

4484. Frequency irregularity in rooms. A. F. B. NICKSON AND R. W. MUNCEY. *Acustica*, **5**, *No.* 1, 44–6 (1955).

Acoustical workers dissatisfied with classical reverberation time measurements have proposed other measurements, often on the basis of ease of instrumentation. Frequency irregularity is one which appears to be gaining favour. Comparisons are here made between the sound used in such a test and those commonly occurring in music. It is shown that the test overlooks a significant variable, namely that common sounds are frequency modulated. Comparative tests of frequency irregularity with pure and frequency modulated tones show that large differences occur. A.

534.844

4485. Interference patterns in reverberant sound fields. R. V. WATERHOUSE. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 247–58 (*March*, 1955).

In a reverberant sound field, where at all points equal mean energy flows in all directions, it is shown that the sound energy is distributed into interference patterns at the reflecting boundaries. Thus the mean

energy density is not uniform at all points in the field. For a perfectly reflecting plane surface that is large compared with the wavelength, the interference pattern can be expressed as a mean square sound pressure varying as $(1 + \sin 2kx/2kx)$ where x is the distance from the surface and k is the wave-number. Corresponding expressions are derived for the mean squared particle velocity and the mean energy density. The energy level at the surface is found to be 2·2 db higher than at points further away where the interference patterns are negligible. Similar expressions are derived for the interference patterns formed by two and three reflectors at right angles, as at the edges and corners of a room. The largest departure from uniformity occurs in a corner where the mean squared pressure is 9 db higher than at remote points. The effects of such interference patterns on transmission loss and reverberation room measurements are discussed briefly. The patterns are not much affected by the frequency bandwidths habitually used in room acoustics. Experimental confirmation of the theory is given. A.

534.862.4 : 621.3.018.78 : 621.383.4

4486. Nonlinear distortions caused by linear resistance of a photoconductive cell. P. V. KORNOUKHOV. *Zh. tech. Fiz.*, **24**, *No.* 6, 993–6 (1954) In Russian.

In the reproduction of film sound tracks by means of a linear photoconductive cell load resistance (for a given working voltage and second harmonic distortion) the signal intensity across the load resistance does not depend on the photoconductive activity of the cell. Also, for a given amplitude of the working voltage and the resulting signal intensity, for all values of load resistance and illuminations of the surface of the photo-element, the second harmonic distortion is constant. An experiment with lead sulphide for the purpose of sound reproduction of film sound tracks shows agreement with theory.

Z. F. WOJNAR

534.88

4487. Effect of rain upon underwater noise levels. T. E. HEINDSMANN, R. H. SMITH AND A. D. ARNESON. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 378–9 (*March*, 1955).

Measurements during two heavy rainstorms through an off-shore calibrated hydrophone system showed an increase of up to 25 db in the 20 to 20 000 c/s band pressure level as compared to the ambient level before and after. During the period of heaviest rainfall the pressure spectrum level was approximately constant at -23 db/1 dyne. cm^{-2} from below 1 kc/s to above 10 kc/s, and apparently extends to beyond 40 kc/s. The pressure spectrum level of the ambient noise can be calculated from the wind force and from a reasonable estimate of the intensity of rainfall. A.

OPTICS . RADIATION . SPECTRA 535

535.12 : 535.3

4488. New transition to ray optics. R. SCHILLER. *Phys. Rev.*, **97**, *No.* 6, 1421–8 (*March* 15, 1955).

It is shown that it is possible to make a transition from the vector wave equation to ray optics. However, because of the possibility of polarization of the waves, it is no longer true that the rays will be normal to a given wave surface, $\phi(x) = \text{constant}$. In place of the usual curl-free velocity field that is defined by a scalar wave equation it is found that the new velocity field depends upon parameters that express its vorticity. The expression for the velocity, and thus the direction of the rays, agrees in magnitude and direction with the time-averaged Poynting vector, except for a term that is the curl of a vector, and which can be interpreted as the intrinsic vorticity of the medium. The methods employed in relating the motion of electromagnetic waves to the motion of a field of particle-like trajectories are equally applicable to other wave fields that possess internal degrees of freedom. The Pauli and Dirac theories of the electron make use of wave fields of this type. However, in this paper, no attempt is made to give such an interpretation to these theories. A.

535.214.6

4489. Concerning an experiment of Nichols and G. Hull, and photophoresis. P. TAUZIN. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 10, 1070–2 (*March* 7, 1955) In French.

The repulsion produced by a beam of light incident on carbon particles falling through a vacuum of the order of 10^{-4} mm Hg cannot be attributed to radiation pressure, as similar particles in the light beam are not affected. Radiation pressure would also exert a larger force on metallic particles than on carbon, which is contrary to observation. It is therefore concluded that the effect is due to photophoresis.

N. CORCORAN

535.231

4490. On the formulation of Kirchoff's law and its use for a suitable definition of diffuse reflection factors. C. V. FRAGSTEIN. *Optik*, **12**, *No.* 2, 60–70 (1955) In German.

Sets out the relations between the constants of emission, absorption and reflection, both for a definite angle to a surface, and for the constants integrated over a hemisphere. The method of measuring flame temperature depending on Kirchhoff's law is valid only if the absorption properties of the flame have rotational symmetry. Coefficients of diffuse reflection are defined and reciprocity relations discussed. A summary of definitions and relations is given.

G. F. LOTHIAN

535.242

4491. Visual photometric measurements of a field of variable luminance gradient. A. FIORENTINI, M. JEANNE AND G. TORALDO DI FRANCIA. Letter in *Optica Acta*, **1**, *No.* 4, 192–3 (*Feb.*, 1955) In French.

This interesting investigation of the Mach effect shows that the subjective changes of a pattern "uniform light—linear decrease to—uniform dark" do not follow the physical ones. At the beginning of the decrease the luminance appears to rise far above the "uniform light" level. It then decreases along a line parallel to, but above, the physical slope.

R. A. WEALE

535.3 : 535.12

4492. The theory of the propagation of light in polycrystalline media. C. V. RAMAN AND K. S. VISWANATHAN. *Proc. Indian Acad. Sci. A*, **41**, *No.* 2, 37–44 (*Feb.*, 1955).

A formula based on wave-theoretical considerations is deduced which gives the coefficient of extinction of plane-polarized light traversing a polycrystalline aggregate in terms of the wavelength of the light, the size of the particles and their birefringence. The general formula covers the case where the particles have preferred orientation expressible by three different probability numbers for three mutually perpendicular directions, and the special case of isotropic orientation is readily derivable therefrom. The significance of the results is discussed in relation to the facts of observation. A.

535.315

4493. The measurement of Abbe inverting and erecting prisms. H. JENSEN. *Optik*, **12**, *No.* 3, 150–2 (1955) In German.

Simple geometrical and optical relationships of the two types of prism are derived. These enable the necessary size and weight of glass to be obtained from graphs. R. W. FISH

535.317.1

4494. The influence of weak aberrations on image contrast. A. MARÉCHAL. *Optik*, **12**, *No.* 3, 118–22 (1955) In French.

The intensity in the diffraction image is derived for a number of simple objects, points, lines, periodic structures, etc. A table giving the tolerance, based upon a 20% loss of contrast, for various aberrations in coherent and incoherent light is given. R. W. FISH

535.317.1

4495. Studies on the image formed by lenses. I. On the characteristics of an image and their quantitative representation. G. KUWABARA. *J. Opt. Soc. Amer.*, **45**, *No.* 4, 309–19 (*April*, 1955).

The intensity distributions of light in the images of a luminous line and a surface boundary formed by lenses with spherical aberration were measured by means of photoelectric photometry, and the following quantities were introduced in order to represent the characteristics of the image quantitatively. They are, for a luminous surface boundary, the distances between the geometrical image of the surface boundary and the points where the light intensity falls to 0·1, 0·02 and 0·01 of that at the bright part; for the luminous line of finite width, the amount of light concentrated in the centre of the image core. The quality of an image depends upon the diffraction of light as well as the amount of residual aberration, but these four quantities seem to be sufficient in expressing the performance of a lens in a quantitative way. It was also found that the best focus of a lens is neither the image plane which gives the minimum halo light nor that which has highest resolving power, but the image plane which gives the maximum light concentration in the centre of the line image. A.

535.317.25 : 771.534.55

4496. The resolving power of the system, "objective-emulsion." V. BLUMOVÁ AND J. HRDLIČKA. Letter in *Czech. J. Phys.*, **4**, *No.* 4, 504–6 (*Nov.*, 1954) In French.

The relationship between the overall resolving power of the system and those of the objective and emulsion is deduced. It is shown that the values deduced agree with the measured values in the case of the experimental results quoted by Couder. This method is said to give better agreement than other earlier formulae. 11 references are given. R. W. FISH

535.317.3/.4

4497. Simultaneous correction of meridian aberrations. I. Preliminaries. F. A. LUCY. *J. Opt. Soc. Amer.*, **45**, *No.* 4, 320–2 (*April*, 1955).

Before correcting a lens system for aberrations of the meridian section, it is economical to reach desired values for the power, Petzval sum and longitudinal chromatic aberration. Approximate values derived from the equivalent doublet can be rapidly refined by an iterative paraxial trace method. A.

535.317.3/.4

4498. Simultaneous correction of meridian aberrations. II. Graphical method. F. A. LUCY. *J. Opt. Soc. Amer.*, **45**, *No.* 4, 323–7 (*April*, 1955).

After establishment of the correct focal length, axial chromatic aberration and Petzval sum, the meridian section aberrations (either third-order or trigonometrically exact) of a lens system can be simultaneously corrected by a graphical method which uses data from digital traces. For a given object point and aperture zone, a lens system may afford several parameter sets which yield solutions of the problem, or there may be none within a given range of parameters. The method finds all existing solutions, or, if there are none, will indicate the variations probably necessary to reach a parameter range which does contain solutions. A.

535.32 : 534.21

4499. Refraction of light in solids by ultrasonic waves. K. S. IYENGAR. *Proc. Indian Acad. Sci. A*, **41**, *No.* 1, 25–9 (*Jan.*, 1955).

The Lucas–Biquard effect of optical refraction in a sound field is experimentally studied in glasses. It is shown that the effect enables the determination of the absolute changes of refractive index, the ratio of elasto-optical constants and the elastic constants of amorphous and crystalline solids. A.

535.33

4500. Emission spectra in the near infra-red. B. KLEMAN AND B. LILJEQVIST. *Ark. Fys.*, **9**, *Paper* 25, 377–83 (1955).

A small spectrometer with interchangeable grating and prism has been used for the study of emission spectra in the near infrared from various conventional light sources. The detector consists of a PbS cell and the amplifying system is based upon the phase-sensitive detector principle. The efficiency of the spectrometer in recording line and band spectra from discharge tubes, King's furnace and an acetylene-air flame is discussed. In the furnace spectrum a new band with its head at 0·86 μ due to CrH is found. The flame spectra of barium, chromium and vanadium are shown to have their main emission concentrated to bands in the near infrared region. A.

535.33

4501. Microspectrography. M. FRANÇON AND H. ROYER. *Rev. Opt.*, **34**, *No.* 1, 25–9 (*Jan.*, 1955) In French.

A review article giving some details of equipment for use in the i.r. region and discussing the factors limiting the accuracy of absorption measurements.

R. W. FISH

535.33.03

4502. A simple arrangement for the production of the continuous Lyman spectrum in the far ultraviolet. J. ROMAND, G. BALLOFFET AND B. VODAR. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 4, 412–15 (*Jan.* 24, 1955) In French.

535.33.03

4503. Hollow iron cathode discharge as source for wavelength and intensity standards. H. M. CROSSWHITE, G. H. DIEKE AND C. S. LEGAGNEUR. *J. Opt. Soc. Amer.*, **45**, *No.* 4, 270–80 (*April*, 1955).

A sealed-off hollow cathode discharge tube with iron electrodes and rare gas filling is described which will give an iron spectrum with very sharp lines and intensities of high reproducibility. Extensive data are given of the dependence of the iron intensities on the character of the rare gas, its pressure, and the discharge current. For most purposes a neon filling at about 3 mm pressure is recommended. The lines of such a tube are recommended for wavelength standards. They may serve as intensity standards with the proper precautions. A.

535.33.03

4504. Interferometric wavelengths of iron lines from a hollow cathode discharge. R. W. STANLEY AND G. H. DIEKE. *J. Opt. Soc. Amer.*, **45**, *No.* 4, 280–6 (*April*, 1955).

Interferometric wavelength measurements (3570 Å to 5709 Å) are given for 189 iron lines produced by a hollow cathode discharge. The lines are considerably sharper than those of the iron arc and the available evidence shows that the wavelengths are invariant with any changes in operating conditions of the tube. The hollow cathode discharge tube in neon with iron electrodes appears to be the best source of standards for wavelength measurements. A.

535.33.07

4505. The design and construction of a 22-foot direct-reading optical spectrometer. T. LEE. *Appl. Spectrosc.*, **8**, *No.* 4, 174–84, 186, 188, 190, 192, 194, 196, 198, 200, 202, 204, 206–7 (*Nov.*, 1954).

To meet a number of spectrochemical problems involving relatively complex spectra, a versatile grating spectrometer having high resolution and dispersion and using photomultiplier tubes to measure the intensities of the spectral lines was constructed. A concave diffraction grating having a radius curvature of 21 ft 10 in. and ruled with 15000 lines per in. over a 5 in. surface was used in Eagle mounting designed to cover continuously the range from 2000 Å in the first order to 5800 Å in the fourth order. Five feet of spectrum are available at any setting of the instrument. To minimize backlash and spurious motion, kinematic principles were used in the design of the adjustments. Vibration absorbers and dampers were used to minimize the effects of vibration, and constructing the instrument in a completely enclosed room located within an air-conditioned area minimized the effects of temperature changes. Either visual or photographic means may be used to position the exit slits and to adjust the optics. Both scanning and integration techniques are available. A.

535.33.07

4506. A furnace and a cryostat. J. LECOMTE. *Rev. Opt.*, **34**, *No.* 1, 22–5 (*Jan.*, 1955) In French.

A furnace and cryostat for use with an infrared spectrograph are described in detail, and some account of the work carried out with them is given.

R. W. FISH

535.33.07

4507. An achromatic scanning device. J. N. SHEARER AND T. A. WIGGINS. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 2, 133–4 (*Feb.*, 1955).

A movable mirror system for traversing a small region of spectrum over the exit slit of a spectrometer.

G. F. LOTHIAN

535.33.07

4508. A new infrared microcell. W. H. T. DAVISON. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 3, 227 (*March*, 1955).

A rocksalt cell requiring less than 1 μl. for a thickness of 0·001 cm. G. F. LOTHIAN

535.33.07

4509. Time delays of spectrograph outputs by low-pass filters. W. E. SMITH. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 3, 227–8 (*March*, 1955).

A discussion of the errors of apparent frequency of an absorption band shown by a spectrometer as a function of the rate of scanning and of the time constants of the recording instruments. D. H. WHIFFEN

535.33.07

4510. Stigmatic plane grating spectrograph with order sorter. R. F. JARRELL. *J. Opt. Soc. Amer.*, **45**, *No.* 4, 259–69 (*April*, 1955).

A new plane-grating spectrograph has been developed to give in a compact mounting a stigmatic image, a nearly flat focal curve, and resolving powers greater than 300000 at dispersions up to 0·2 Å/mm. The performance of the instrument in the low orders is at least as good as that of a Wadsworth concave grating spectrograph of the same focal length. However, the upper wavelength limit is increased to 40000 Å or even 60000 Å, in the first order of a 7500 line/inch grating. At such settings the many overlapping orders are separated by an "order sorter," a prism predispersor crossed with the grating dispersion. This makes it possible to obtain in a single exposure on 30 in. of plate the continuous wavelength range 2140 Å to 6340 Å at dispersions ranging from 0·44 Å/mm to 1·1 Å/mm. A.

535.33.07

4511. Slit for interposing spectra on echellegrams. L. S. BROOKS. *J. Opt. Soc. Amer.*, **45**, *No.* 4, 300–1 (*April*, 1955).

A slit for spectrographs with cross dispersion has been constructed. The function of the slit is illustrated by three spectra interposed on an echellegram. A.

535.33.07 : 537.312.5

Photoconductive detectors for infra-red spectroscopy. *See Abstr.* 4673

535.331 : 539.152.2

4512. On the hyperfine structure of the Tm II spectrum and the nuclear moments of Tm^{169}. K. H. LINDENBERGER AND A. STEUDEL. Note in *Naturwissenschaften*, **42**, *No.* 2, 41–2 (1955) In German.

A Fabry–Perot spectroscopic analysis of 20 lines between 3500 and 4000 Å leads to nuclear spin $\frac{1}{2}$ and (in three independent ways) to a magnetic moment of $\mu_I = -0{\cdot}20 \pm 0{\cdot}03$ n.m. in contradiction with the shell model. W. J. SWIATECKI

535.333

4513. The band spectrum of the Ag_2 molecule. B. KLEMAN AND S. LINDKVIST. *Ark. Fys.*, **9**, *Paper* 26, 385–90 (1955).

A vibrational analysis has been carried out for a blue band system of Ag_2. A King's furnace was used as light source and the spectrum was photographed both in emission and absorption. The appearance of the system is complicated both by the near equality of the ΔG values for the higher vibrational levels and by the enhancement of the last observed bands due to predissociation. The Ag_2 molecule is found to be somewhat less stable than the Cu_2 and Au_2 molecules. A.

535.333

4514. Relative vibrational transition probabilities of the CN violet bands. A. L. FLOYD AND R. B. KING. *J. Opt. Soc. Amer.*, **45**, *No.* 4, 249–55 (*April*, 1955).

The relative intensities of the band heads in the $\Delta v = 0$, $+1$ and -1 sequences of the $B^2\Sigma - X^2\Sigma$ violet bands of CN have been measured in low dispersion emission spectra excited in a graphite-tube electric furnace. In the furnace the CN radicals are in thermal equilibrium at a known temperature so that their distribution among the vibrational and rotational energy levels can be calculated. This permits relative vibrational transition probabilities to be derived from the measured intensities of the band heads. Various factors which affect the observed intensities were investigated and corrections for them obtained. These factors include the variations in rotational line structure comprising the band heads, the effect of overlapping rotational lines of neighbouring bands, and the effects of self-reversal and self-absorption. The vibrational transition probabilities obtained are compared with theoretical data calculated by different methods. A.

535.333

4515. On the band spectrum of CrH. B. KLEMAN AND B. LILJEQVIST. *Ark. Fys.*, **9**, *Paper* 21, 345–7 (1955).

Three systems of CrH appear in a King's furnace. A vibrational analysis is given for a red-degraded system with (0, 0) band at 8611 Å. The known band at 3675 and a new one at 3290 Å are also obtained and attributed to separate electronic transitions.

A. G. GAYDON

535.333

4516. The $^3\Pi \rightarrow {}^3\Sigma$ system of the ND radical observed in emission in the decomposition of heavy hydrazoic acid, N_3D. G. PANNETIER, H. GUÉNEBAUT AND A. G. GAYDON. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 9, 958–60 (*Feb.* 28, 1955) In French.

The spark-initiated decomposition of gaseous N_3D has been studied spectroscopically and shows new bands of the $^3\Pi \rightarrow {}^3\Sigma$ system of ND. A vibrational array is given for seven Q heads; four others are provisionally assigned as R or P heads. Comparison of vibrational constants with those previously obtained for NH [see Abstr. 6846 (1951)] gives $\rho = 0{\cdot}73$ and confirms both analyses. A. G. GAYDON

535.333

4517. The band spectrum of vanadium oxide. A. LAGERQVIST AND L.-E. SELIN. Note in *Naturwissenschaften*, **42**, *No.* 3, 65 (1955) In German.

A new rotational analysis of the visible bands of VO shows that they arise from a $^2\Delta - {}^2\Delta$ transition, with the following constants:

$B'_e = 0{\cdot}495_3\,\text{cm}^{-1}$ $\alpha'_e = 0{\cdot}003_5\,\text{cm}^{-1}$, $r'_e = 1{\cdot}67$ Å
$B''_e = 0{\cdot}548_0$ $\alpha''_e = 0{\cdot}003_4$ $r''_e = 1{\cdot}59$.

R. F. BARROW

535.333

4518. New emission bands produced by electrical excitation of ammonia. H. SCHÜLER, A. MICHEL AND A. E. GRÜN. *Z. Naturforsch.*, **10a**, *No.* 1, 1–2 (*Jan.*, 1955) In German.

Describes new bands in the region 5200–8500 Å, produced in ammonia discharges at pressures ~ 1 atmosphere. NH_3 and ND_3 were investigated; large isotope shifts were observed. J. D. CRAGGS

535.333 : 536.46

4519. Infrared emission and absorption in an ammonia-oxygen diffusion flame. D. A. DOWS, E. WHITTLE AND G. C. PIMENTEL. *J. chem. Phys.*, **23**, *No.* 3, 499–502 (*March*, 1955).

An ammonia-oxygen diffusion flame has been studied spectroscopically in the infrared region using a flat diffusion flame of the kind described by Wolfhard and Parker. The emissions of OH, NH_3 and H_2O and the absorptions of NH_3 and H_2O have been studied as a function of position in the flame. Combined with the information obtained earlier by Wolfhard and Parker concerning the distributions of OH, NH and O_2, a complete description of the flame is possible. Evidence is presented that OH is in vibrational as well as rotational equilibrium in the flame. No evidence of infrared emission by NH or NH_2 could be found. A.

535.338.332 : 539.152.2

4520. Determination of the electric quadrupole moments of the Rb^{85} and Rb^{87} nuclei through the measurement of the high-frequency transitions in the $6\,^2P_{3/2}$ term of the Rb atom. H. KRÜGER AND U. MEYER-BERKHOUT. Note in *Naturwissenschaften*, **42**, *No.* 4, 94–5 (1955) In German.

The hyperfine structure of the $6\,^2P_{3/2}$ state of Rb was observed through the depolarization of the fluorescence line as a function of the applied radiofrequency which induced $\Delta F = \pm 1$ transitions. The nuclear magnetic moment interaction constants are A^{85} $8{\cdot}16 \pm 0{\cdot}06$, A^{87} $27{\cdot}63 \pm 0{\cdot}1$ Mc/s; the quadrupole coupling constants B^{85} $8{\cdot}40 \pm 0{\cdot}4$, B^{87} $4{\cdot}06 \pm 0{\cdot}2$ Mc/s and the derived quadrupole moments $Q(Rb^{85}) = +0{\cdot}29 \pm 0{\cdot}02$ and $Q(Rb^{87}) = +0{\cdot}14 \pm 0{\cdot}01 \times 10^{-24}\,\text{cm}^2$. D. H. WHIFFEN

535.338.333

4521. Theoretical determination of the isotope shift in the spectrum of the carbon atom. A. P. YUTSIS, A. S. NAKONECHNŸĬ AND G. K. TSYUNAĬTIS. *Zh. éksper. teor. Fiz.*, **25**, *No.* 6(12), 683–7 (1953) In Russian.

An expression is derived for the specific shift for the configuration $1s^2 2s^2 2p^k 3s^{2-k}$ ($k = 1,2$) for the C atom, in the 2-configurational approximation $1s^2 2s^2 2p^k 3s^{2-k} - 1s^2 2p^{k+2} 3s^{2-k}$. With the aid of one-electron self-consistent Hartree wave-functions the isotope shift for the transition $1s^2 2s^2 2p3s - 1s^2 2s^2 2p^3$ is calculated both in the 1- and 2-configurational approximations. The shift is smaller in the latter case, the decrease for the $^1P - {}^1S$ transition being about 10 times greater than for $^1P - {}^1D$ or $^3P - {}^3P$. The experimental value for $^1P - {}^1S$ lies between the 1- and 2-configurational approximations, several times nearer the latter. W. J. SWIATECKI

535.338.334

4522. Pressure broadening of the rubidium lines $\lambda = 7800,23$ Å and $\lambda = 7947,60$ Å and their Zeeman components in absorption. J. TOMISER. *Acta phys. Austriaca*, **9**, *No.* 1, 18–26 (1954) In German.

The methods previously described [Abstr. 1684 (1955)] are used up to $p = 0{\cdot}08$ mm Hg. Greater broadening is observed for $\lambda = 7800$ Å and also for its Zeeman components. In all cases, broadening is not proportional to p. At $p > 3\times10^{-4}$ mm additional forbidden Zeeman components appear. G. F. LOTHIAN

535.338.4

4523. Vibrational temperatures in C_2 (Swan) system in rare gases and Ramsauer effect. N. R. TAWDE AND V. RAJESWARI. Letter in *J. sci. industr. Res.*, **13B**, *No.* 12, 879–80 (*Dec.*, 1954).

Describes measurements of excitation (vibrational) temperatures in discharges between carbon electrodes in the rare gases at pressures varying from about 5 to 30 mm Hg. The temperatures fall between 2000 and 12000°K, and their variations with the nature of the carrier gas are discussed. J. D. CRAGGS

535.343

4524. One-to-two millimeter wave spectra of TCl and TBr. C. A. BURRUS, W. GORDY, B. BENJAMIN AND R. LIVINGSTON. *Phys. Rev.*, **97**, *No.* 6, 1661–4 (*March* 15, 1955).

The $J = 0 \rightarrow 1$ rotational transitions of TCl and TBr were measured at 1·36 mm and 1·74 mm wavelengths respectively. Values for the constants $\nu_0(0 \rightarrow 1)$, B_0, B_e, r_0, r_e, eQq for TCl^{35}, TCl^{37}, TBr^{79}, TBr^{81} were calculated from these measurements and from α_e and D obtained from i.r. data. From the TBr measurements and similar measurements on DBr made previously, the mass ratio $m_T/(m_D) = 1{\cdot}497\,47$ was obtained. A.

535.343

4525. Studies of absorption spectra. II. Theory of copper (II)-spectra. C. J. BALLHAUSEN. *K. Danske Vidensk. Selsk., mat.-fys. Medd.*, **29**, *Paper* 4, 18 *pp.* (1954).

The cupric ion, with nine 3*d* electrons, is treated as having one *d* positron. The wave equation is considered, using hydrogen-like wave-functions and considering perturbations due to (1) an array of up to 6 point charges or (2) up to 6 dipoles. Spin-orbit interaction is neglected. The resulting expressions are applied to $[CuCl_4]''$, $[CuBr_4]''$ and $[Cu(NH_3)_n(H_2O)_{6-n}]^{++}$, the results being given in detail elsewhere [J. Bjerrum, C. J. Ballhausen and C. K. Jörgensen, *Acta chem. Scand.*, **8**, 1275 (1954)]. G. F. LOTHIAN

535.343

4526. Studies of absorption spectra. V. The spectra of nickel (II) complexes. C. J. BALLHAUSEN. *K. Danske Vidensk Selsk., mat.-fys. Medd.*, **29**, *Paper* 8, 17 *pp.* (1955).

The Ni^{++} ion is treated as having two *d* positrons, by the method described in the preceding abstract. It is shown that the 3-*F* ground state is split by the perturbing field of 6 dipoles into 3 levels spaced in the proportions 0–1–1·8. Observed spectra of (*a*) $Ni(H_2O)_6^{++}$ and (*b*) $Ni(en)_3^{++}$ in the region 8000–18000 cm^{-1} confirm this result. The doubling of one of the bands of (*a*) may be attributed to *L–S* coupling which has been neglected, but which does not arise in the stronger perturbing fields of (*b*). Calculations on 4-co-ordinated complexes are not easily related to experiment. G. F. LOTHIAN

535.343

4527. Studies of absorption spectra. VI. Actinide ions with two 5-*f*-electrons. C. K. JÖRGENSEN. *K. Danske Vidensk. Selsk., mat.-fys. Medd.*, **29**, *Paper* 7, 21 *pp.* (1955).

A review of measured absorption spectra of compounds containing U^{4+} ions or other ions of similar electronic structure. It is concluded that the configuration of U^{4+} is [radon]-$5f^2$. The interaction of two *f*-electrons is treated by the Condon and Shortley method; calculated and observed levels are in fairly good agreement. 42 references. G. F. LOTHIAN

535.343

4528. Fine structure of the 2·7 micron carbon dioxide rotation-vibration band. W. L. FRANCE AND F. P. DICKEY. *J. chem. Phys.*, **23**, *No.* 3, 471–4 (*March*, 1955).

The infrared spectrum of CO_2 in the region of 2·7 μ has been remeasured. Five rotation-vibration bands have been identified and analysed in detail. One of these is due to $C^{13}O_2$. The rotational constants obtained were $B_{000} = 0{\cdot}390\,4\ cm^{-1}$ and $D_{000} = 0{\cdot}25\times10^{-6}\ cm^{-1}$. In two of the bands *l*-type doubling occurs, and the values of the splitting constants *q* were determined. A.

535.343

4529. Hydrogen peroxide and its analogues. VI. Infrared spectra of H_2O_2, D_2O_2, and HDO_2. O. BAIN AND P. A. GIGUÈRE. *Canad. J. Chem.*, **33**, *No.* 3, 527–45 (*March*, 1955).

For Pt V, see *J. chem. Phys.*, **9**, 458 (1941). The absorption spectrum of hydrogen peroxide was re-examined with a prism instrument in the region 1·5 to 25 μ. A pair of well-resolved perpendicular bands arising from torsional oscillation of the OH groups were found centred about 460 and 575 cm^{-1}. The overtone band at 3·8 μ was shown to be a hybrid with prominent rotational structure and some indications of doubling. Its assignment to the combination

$\nu_2 + \nu_6$ implies a positive anharmonicity. Four new overtone bands were observed in liquid hydrogen peroxide. The infrared spectrum of deuterium peroxide was measured for the first time in the solid and vapour states. The vapour bands are quite different in appearance from those of hydrogen peroxide. One of the fundamentals, the asymmetric O—D stretching at 2 661 cm^{-1}, was resolved sufficiently to allow calculation of the rotational constants of the isotopic molecule. Mixtures of the two peroxides containing around 40% of HDO_2 were also investigated; from the results the frequency of the as yet unobserved symmetric modes ν_1 and ν_2 could be estimated with fair certainty. The O—O stretching vibration at 11μ was too weak to be located definitely in the spectra of the gaseous peroxides. The structural parameters of the H_2O_2 molecule are now established as follows: $r_{O-O} = 1{\cdot}49 \pm 0{\cdot}01$ Å, $r_{O-H} = 0{\cdot}97 \pm 0{\cdot}01$ Å, $\alpha_{OOH} = 100° \pm 2°$. The O—H and O—D stretching bands were studied in solutions of the three isotopic peroxides in carbon tetrachloride. A.

535.343

4530. Variation of line width with rotational state and temperature in the microwave spectrum of OCS. R. S. ANDERSON. *Phys. Rev.*, **97**, *No.* 6, 1654–60 (*March* 15, 1955).

The earlier measurements on the self-broadening of OCS rotational transitions by Johnson and Slager have been extended. Measurements have been made at constant pressure on seven rotational transitions in the ground vibrational state from $J = 3 \rightarrow 4$ to $J = 15 \rightarrow 16$ and at dry ice and room temperatures. The data have been interpreted by a simple theory which assumes a constant contribution to line width from dipole-dipole interactions and an additional J-dependent contribution from rotational resonance interactions. Empirically determined temperature dependence is introduced for each contribution. This interpretation, when fit to the observed line widths, $\Delta\nu$ results in the expression

$$\Delta\nu = (1\,815/T) + 0{\cdot}00\,321T^{\frac{1}{2}}(J+1)^2 e^{-hBJ(J+1)/kT} \text{ Mc/s}$$

at 1 mm Hg pressure. The collision diameters for OCS are found to be approximately linear functions of the rotational state and independent of temperature. A.

535.343 : 539.132

4531. Fermi resonance in the microwave spectrum of linear *XYZ* molecules. W. LOW. *Phys. Rev.*, **97**, *No.* 6, 1664–7 (*March* 15, 1955).

Measurements of the rotation-interaction constants α_i for the various vibrational states in the microwave spectrum of OCS and OCSe show little consistency. These discrepancies are explained within experimental accuracy as being due to interaction between adjacent vibrational levels with quantum numbers ν_1, ν_2, ν_3 and $\nu_1 - 1$, $\nu_2 + 2$, ν_3. Resonance of this type, called Fermi resonance, has also been found in ICN but the interaction constant is very much smaller. A.

535.343 : 532.77

4532. Absorption spectra of metals in solution. H. BLADES AND J. W. HODGINS. *Canad. J. Chem.*, **33**, *No.* 2, 411–25 (*Feb.*, 1955).

Measurements of the absorption spectra were made on solutions of alkali and alkaline earth metals in ammonia, methylamine, ethylamine, and mixed solvents. In ammonia, a single absorption band was measured which is common to all the metals examined. In the amines and in mixtures of ammonia with methylamine, however, bands were found which were characteristic of the metal employed. A hypothesis has been advanced to explain the existence of the different types of energy traps responsible for the variations in spectra. A.

535.343

4533. Absorption cross-sections in the vacuum ultraviolet. III. Methane. R. W. DITCHBURN. *Proc. Roy. Soc. A*, **229**, 44–62 (*April* 5, 1955).

For Pt II, see Abstr. 849 (1955). Cross-sections for the continuous absorption of radiation by methane in the wavelength range 1 600 to 350 Å have been measured. The absorption is analysed so as to distinguish between absorption leading to photo-dissociation processes and absorption due to photo-ionization. The main photo-ionization process is $CH_4 + h\nu \rightarrow CH_4^+ + e^-$, and the photo-ionization cross-section is measured for free electron energies from 0 to about 20 eV. Little evidence is found for processes such as $CH_4 + h\nu \rightarrow CH_3^+ + H + e^-$. The results are compared with calculations by Dalgarno. The paper includes an account of the technique of photographic spectrophotometry in the region 1 100 to 200 Å. A.

535.343 : 535.375.5

4534. Investigation of the characteristic frequency of the carbonyl groups of some conjugated acids. M. HARRAND AND L. TUERNAL-VATRAN. *Ann. Phys.* [*Paris*] **10**, 5–15 (*Jan.–Feb.*, 1955) In French.

Some organic acids with double bonds near the carbonyl group do not show any characteristic C=O frequency near 1 700 cm^{-1} in their Raman spectra. As it was supposed that this absence was caused by association of the molecules, spectra were taken of such acids in the liquid phase and in solution in various polar and non-polar solvents. Each infrared spectrum showed at least one strong band near 1 700 cm^{-1}, but in the Raman spectra different solvents showed either one or two bands, sometimes very weak. This is explained by the assumption of the existence of associated molecules, mainly dimers, which are bound by hydrogen bridges. If the dimer has a centre of symmetry the band, apart from being shifted, is also doubled. A. J. TAYLOR

535.343 : 535.375.5

4535. Infrared and Raman spectra of fluorinated ethanes. VIII. Pentafluoroethane. J. R. NIELSEN, H. H. CLAASSEN AND N. B. MORAN. *J. chem. Phys.*, **23**, *No.* 2, 329–33 (*Feb.*, 1955).

For Pt VIII, see Abstr. 5962 (1953). The infrared spectrum of gaseous CF_3CF_2H has been observed in the region from 2 to 38μ, and the spectrum of the liquid at −50°c from 2 to 22μ, with the aid of LiF, NaCl, KBr and KRS-5 prisms. The Raman spectrum of gaseous CF_3CF_2H has been photographed with a three-prism glass spectrograph of linear dispersion 15 Å/mm at 4 358 Å. All but one of the fundamental vibration frequencies have been assigned, and the spectra have been interpreted in detail. A.

535.343 : 539.132

4536. Infrared intensities and bond moments in formaldehyde. I. C. HISATSUNE AND D. F. EGGERS, JR. *J. chem. Phys.*, **23**, *No.* 3, 487–92 (*March*, 1955).

The infrared band intensities of formaldehyde have been measured in the gas phase using the pressure broadening method. From the results of the normal co-ordinate analysis and the experimental intensities, the bond moments and their derivatives have been calculated for the three symmetry species. The relative signs of $\partial\mu/\partial Q_5$ and $\partial\mu/\partial Q_6$ have been determined from the investigation of the Coriolis interaction between ν_5 and ν_6. The results chosen from the calculations are: $\mu_{CH} = 0{\cdot}5\ D(C^- - H^+)$, $(\partial\mu/\partial r)_{CH} = 1{\cdot}3\times10^{-10}$ e.s.u., $\mu_{CO} = 1{\cdot}9\ D(C^+ - O^-)$, $(\partial\mu/\partial r)_{CO} = -1{\cdot}9\times10^{-10}$ e.s.u. The B_1 symmetry block gave an abnormally large μ_{CH} of about $1\,D$. A.

535.343 : 539.132

Vibrational spectra of ethyl cyanide. *See Abstr.* 4838

535.343 : 539.133

4537. Microwave spectrum of cyclopentene oxide. G. ERLANDSSON. *Ark. Fys.*, **9**, *Paper* 20, 341–3 (1955).

The microwave spectrum confirms the main structure as a cyclopentane ring with a fused ethylene oxide ring. Assuming the former to be planar the approximate dimensions are C–C 1·52 Å, C–O 1·47 Å and the angle between the planes of the rings 98°.

D. H. WHIFFEN

535.343

4538. Microwave spectrum of ethyl bromide. R. S. WAGNER, N. SOLIMENE AND B. P. DAILEY. Letter in *J. chem. Phys.*, **23**, No. 3, 599 (*March*, 1955).

535.343

4539. Microwave spectrum of *s-trans* acrolein. J. FINE, J. H. GOLDSTEIN AND J. W. SIMMONS. Letter in *J. chem. Phys.*, **23**, *No.* 3, 601 (*March*, 1955).

535.343 : 539.132

4540. Microwave spectrum of methyl mercaptan. I. T. KOJIMA AND T. NISHIKAWA. Note in *J. Phys. Soc. Japan*, **10**, *No.* 3, 240–1 (*March*, 1955).

Both by assignment of microwave lines and by intensity measurements the internal energy barrier in CH_3SH is shown to be $280 \pm 50\,cm^{-1}$.

D. H. WHIFFEN

535.345

4541. On the absorption of ultraviolet radiation by distilled water. J. LENOBLE AND B. SAINT-GUILLY. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 9, 954–5 (*Feb.* 28, 1955) In French.

Absorption coefficients have been measured photographically and values are tabulated for $\lambda = 2\,200$–$4\,000$ Å. For $\lambda < 3\,700$ Å, the values are appreciably less than those given by other authors.

G. F. LOTHIAN

535.345 : 537.311.33

Infrared absorption of Ge near the lattice edge. *See Abstr.* 4654

535.345.6

4542. Conversion filter on gelatine base. H. FESEFELDT AND H. KRAPPATSCH. *Optik*, **12**, *No.* 2, 57 (1955) In German.

Starting from black-body radiation characteristic of a given temperature, it is possible to calculate the absorption spectrum of a filter which alters the proportion of energy at the different wavelengths so as to give the radiation characteristic of another temperature. Results are quoted which indicate that the colour temperature can be increased or decreased with a good approximation to the required spectral distribution. No details of the filters are given.

N. CORCORAN

535.345.6

4543. A generalised theory of the Christiansen experiment. C. V. RAMAN AND K. S. VISWANATHAN. *Proc. Indian Acad. Sci. A*, **41**, *No.* 2, 55–60 (*Feb.*, 1955).

A formula is derived for the transmission coefficient of a Christiansen cell containing particles of a birefringent material whose interstices are filled up by a liquid of suitably adjusted refractive index. The consequences of the formula and especially the influence of the birefringence on the spectral character of the transmitted light are discussed. See also Abstr. 6910 (1949). A.

535.345.6

4544. The Christiansen experiment with birefringent powders. C. V. RAMAN AND M. R. BHAT. *Proc. Indian Acad. Sci. A*, **41**, *No.* 2, 61–6 (*Feb.*, 1954).

Optical effects analogous to those exhibited by isotropic materials in a Christiansen cell are also observable with birefringent materials in a fine state of subdivision. While the transmitted light is fully polarized, the diffusion halo is depolarized in part and exhibits colours between parallel and crossed polaroids which are complementary to each other. A.

535.371

4545. Luminescence studies of uranium-activated alkaline earth tungstates and molybdates. H. GOBRECHT AND W. WEISS. *Z. Phys.*, **140**, *No.* 2, 139–49 (1955) In German.

535.371

4546. Agreement between electron emission and luminescence phenomena of excited crystals. J. LEPPER. *Z. Naturforsch.*, **10a**, *No.* 1, 47–52 (*Jan.*, 1955) In German.

Electrons from traps recombine to give phosphorescence emission but some are emitted from the phosphor surface. Electron emission can thus be used as an indicator of variation of conduction electron density with time. G. F. J. GARLICK

535.371

4547. Infrared light emission from germanium at low temperatures. R. KESSLER. Note in *Z. Naturforsch.*, **10a**, *No.* 1, 87–8 (*Jan.*, 1955) In German.

If germanium is slowly cooled to say −183°c and simultaneously irradiated with 1·9 to 2·8 μ radiation, on warming up again enhanced light emission is observed. C. A. HOGARTH

535.371

4548. The effect of superposing a small alternating excitation on the steady excitation of a luminescent material. K. F. STRIPP AND R. H. BUBE. Letter in *J. appl. Phys.*, **26**, *No.* 2, 251–2 (*Feb.*, 1955).

535.371

4549. Scintillations and luminescence in unactivated NaI. W. Van Sciver and R. Hofstadter. Letter in *Phys. Rev.*, **97**, *No.* 4, 1181 (*Feb.* 15, 1955).

At 80°K the scintillation efficiency of unactivated NaI is of the same order as that of NaI–Tl crystals at room temperature, with decay time of 3×10^{-8}sec at 100°K (25×10^{-8}sec for NaI-Tl at 20°C).

G. F. J. GARLICK

535.371

4550. Luminescence of crystals at low temperatures. VI. *T* to *S* transition of hexachlorobenzene. P. Pesteil, L. Pesteil and R. Kara. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 9, 960–2 (*Feb.* 28, 1955) In French.

535.371

4551. Some effects of infrared irradiation on ZnSCdS phosphors with copper activators. K. Nakamura. Note in *J. Phys. Soc. Japan*, **10**, *No.* 3, 236–7 (*March*, 1955).

535.371

4552. Absolute quantum efficiency of photofluorescence of anthracene crystals. G. T. Wright. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 4, 241–8 (*April*, 1955).

The fluorescence characteristics of organic crystals differ appreciably from those of the emitting molecules due to self-absorption of the molecular fluorescence. These differences are investigated and properties of the fluorescence of the crystal are related to the corresponding properties of the molecular fluorescence; the equations developed are made the basis of an experimental determination of molecular quantum efficiencies of photofluorescence for the crystalline state. This method avoids the considerable errors involved in a direct measurement which are occasioned by having to integrate numerically over the whole sphere of emission inside an optically anisotropic crystal the fluorescence intensity that is measured directly only within a certain solid angle external to the crystal. The method developed is particularly applicable to crystalline anthracene which has considerable overlap of absorption and fluorescence spectra. Experimental data for this substance are presented. These include the molecular and crystal fluorescence spectra and decay times; the latter are found to be $6\cdot4\pm0\cdot2$ mμsec and $18\cdot0\pm0\cdot5$ mμsec respectively. The molecular quantum efficiency of photofluorescence of crystalline anthracene at a temperature of 290°K is found to be $0\cdot94\pm0\cdot02$ which is reduced, by the effects of self-absorption of fluorescence, to a quantum efficiency for the crystal of $0\cdot80\pm0\cdot05$; efficiencies of photoluminescence are found to be the same within the limits of experimental error. A.

535.371 : 534.39

4553. Luminescence produced as a result of intense ultrasonic waves. V. Griffing and D. Sette. *J. chem. Phys.*, **23**, *No.* 3, 503–9 (*March*, 1955).

This has been investigated in a number of water solutions and organic liquids in the frequency range 0·66–2·0 Mc/s. Together with direct visual tests, quantitative measurements have been performed for which a photometric method has been developed. The results show that luminescence, when it does occur, is always present with cavitation and starts at the same sound intensity as cavitation. A quantitative relationship is established between intensity of luminescence and chemical yield induced by ultrasonics. From this it is concluded that, at least in some of these cases, the phenomenon is chemiluminescence. None of the organic liquids tested showed any luminescence except for nitrobenzene in which the luminescence was very weak in the frequency range and under the physical conditions examined. It is not possible at present to conclude whether this weak luminescence is due to some chemical reaction occurring in it or to a different process. An apparent frequency dependence for the intensity of luminescence was observed; however, it is shown that the threshold of cavitation is the frequency-dependent phenomenon. A.

535.371 : 537.312.5 : 534.39 : 534.321.9

The effect of ultrasound on the conductivity and fluorescence of zinc and cadmium sulphide crystals. *See Abstr.* 4467

535.371 : 537.542

4554. Compacted scintillators. L. Reiffel and H. V. Watts. Letter in *Phys. Rev.*, **97**, *No.* 6, 1714 (*March* 15, 1955).

Clear masses of NaI(Tl) and KBr(Tl) 1·3 cm diameter and 0·4 cm thickness have been obtained by compression of the powders in a double piston die. Other materials such as anthracene and ZnS–Ag do not give good results. G. F. J. GARLICK

535.372

4555. The vibrational structure of the naphthalene fluorescence spectrum in solution and for crystals. H. C. Wolf. *Z. Naturforsch.*, **10a**, *No.* 1, 3–9 (*Jan.*, 1955) In German.

535.375.5

4556. Application of photoelectric recording method to the Raman spectrum analysis of molecules. Ya. S. Bobovich and D. B. Gurevich. *Zh. éksper. teor. Fiz.*, **27**, *No.* 3(9) 318–32 (1954) In Russian.

The difficulty of obtaining accurate quantitative results from the Raman spectra is connected with the faintness of lines. Disadvantages of photographic recording are obvious; seven references are listed of research work done on photoelectric recording of these lines. An apparatus with a high light-transmitting capacity for the photoelectric recording of faint spectra in the visible region is illustrated and described. It includes an autocollimating glass monochromator, a recording apparatus, a photomultiplier with a d.c. amplifier, and a light source. Results of numerous tests show that the apparatus is suitable for the analysis of hydrocarbon mixtures and for quantitative measurements of degrees of depolarization of Raman spectrum lines [see also Abstr. 7156 (1950)]. F. LACHMAN

535.375.51

4557. Intensity in the Raman effect. I. Reduction of observed intensity to a standard intensity scale for Raman bands in liquids. H. J. Bernstein and G. Allen. *J. Opt. Soc. Amer.*, **45**, *No.* 4, 237–49 (*April*, 1955).

A standard intensity scale for Raman bands in liquids has been proposed which is referred to the

Raman band at 458 cm^{-1} in CCl_4 taken under the same experimental conditions. Standard intensities are obtained from the photoelectrically registered spectra by correcting for convergence error, spectral sensitivity of the photomultiplier tube, optical density of the sample and reflection loss, and reduction to scattering per molecule. In all cases integrated intensities are used. Calculation of the effect of a triangular slit function on a Lorentz type Raman contour yields correction factors for converting the product of the peak intensity and the observed half band width to integrated intensities. Standard intensities are given for the Raman bands of liquid CH_2Cl_2, $CHCl_3$ and CCl_4. The apparent departure of the intensity from its linear dependence on concentration is also discussed. A.

535.376/.377

4558. Thermoluminescence and fluorescence in alkali halide crystals induced by soft X-ray. S. P. KELLER AND J. J. CLEMMONS. Letter in *J. chem. Phys.*, **23**, *No.* 3, 586–7 (*March*, 1955).

535.377

4559. Thermoluminescence of alkali halide phosphors. H. N. BOSE. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 4, 249–52 (*April*, 1955).

Thermoluminescence curves of NaCl, KCl, NaCl : Tl, KCl : Tl and mechanical mixtures of TlCl with NaCl and KCl have been recorded. The samples were excited by 10 kV cathode rays at liquid oxygen temperature, and a high rate of heating (5–6 deg sec^{-1}) was employed. The emissions and the temperatures were continuously recorded during heating. The trap depths of these phosphors have been estimated and the effects of heat treatment on the samples studied. A.

535.39

4560. The optical properties of isotropic and inhomogeneous thin metal layers. F. ABELÈS. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 10, 1068–70 (*March* 7, 1955) In French.

Some relations are given between the various amplitude and phase changes occurring on reflection at and transmission by metal layers whose complex dielectric constant varies through their thickness but is invariant along directions parallel to their surfaces. Their thickness is assumed to be a small fraction of the incident wavelength. It is shown that such layers are characterized by four parameters, as opposed to three for completely homogeneous layers, and that measurements of phase changes as well as amplitude factors are required to specify their properties completely. D. G. AVERY

535.411

4561. A sensitive wave-front tilter. M. DE. *J. sci. Instrum.*, **32**, No. 4, 141–2 (*April*, 1955).

The possibility of using rotation of a small-angle prism for the purpose of tilting plane waves to scan a diffraction image has been investigated. It is found that this provides a very useful method of tilting plane waves by amounts of the order of a second, where the conventional methods fail to possess either reproducibility or precision. A.

535.417

4562. The application of shearing interferometry to routine optical testing. D. S. BROWN. *J. sci. Instrum.*, **32**, *No.* 4, 137–9 (*April*, 1955).

Methods of interpretation of shearing interferograms, and the use of the interferogram height as a criterion of optical quality are considered. Two interferometers of simple design are described. A.

535.417 : 541.127

A photoelectric recording interferometer. *See Abstr.* 5035

535.42

4563. The concept of coherence in optics. A. BLANC-LAPIERRE AND P. DUMONTET. *Rev. Opt.*, **34**, *No.* 1, 1–21 (*Jan.*, 1955) In French.

Diffraction problems have largely been studied with either coherent or incoherent objects. The case of partial coherence can be considered as an application of correlation theory, and developed systematically by the theory of random functions. The authors consider monochromatic, nearly monochromatic and a generalized light source. Some statistical properties of light are briefly discussed. R. W. FISH

535.421

4564. Diffraction grating study: derivation and experimental verification of the cause of tilted spectral images. S. J. SAGE AND R. E. SWING. *J. Opt. Soc. Amer.*, **45**, *No.* 4, 256–8 (*April*, 1955).

A theoretical analysis has been made of a diffraction grating defect in which the ruled lines are fanned out uniformly and appear to intersect at a common point in space. The resulting phenomenon, a tilting of the spectral image, is formulated and experimentally verified. The theory further predicts a loss of resolving power under certain conditions, and it is suggested that this may be the cause of heretofore inexplicable losses in resolving power for otherwise perfect gratings. A.

535.43 : 537.228.1

4565. Theory of the scattering of light by strongly piezoelectric crystals. J. CHAPELLE AND L. TAUREL. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 7, 743–5 (*Feb.* 14, 1955) In French.

Thermal waves in such a crystal give rise to electric fields and so to changes in refractive index ($\delta\mu$) and thus form "a new cause of light scattering." Expressions for $\delta\mu$ are developed. G. F. LOTHIAN

535.43 : 538.566 : 534.26

The scattering of a scalar wave by a semi-infinite rod of circular cross section. *See Abstr.* 4464

535.43 : 541.64

4566. Light scattering from very long rod-like particles and an application to polymerized fibrinogen. E. F. CASASSA. Letter in *J. chem. Phys.*, **23**, *No.* 3, 596–7 (*March*, 1955).

Measurements show that polymerization involves "a lateral dimerization together with the longitudinal polymerization of much greater extent." G. F. LOTHIAN

535.43.07

4567. An improved solution light scattering cell. F. P. PRICE AND B. H. ZIMM. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 3, 229 (*March*, 1955).

The design permits measurements as close as 20° to the forward direction. G. F. LOTHIAN

535.43.07 : 541.182.2/3

4568. A comparison photometer to measure light scattering of aerosols and gases, using the latter as light-scattering standards. F. T. Gucker, Jr and A. H. Peterson. *J. Colloid Sci.*, **10**, *No.* 1, 12–23 (*Feb.*, 1955).

Describes the design and operation of an extremely sensitive instrument for automatic measurement of light scattered from aerosols and gas molecules. The lower limit of measurement with aerosols is determined by the scattering from the air molecules in which the particles are dispersed. The scattered light and a suitably attenuated portion of the direct light fall successively upon a photomultiplier tube, the anode current of which passes through a high resistor to give an *IR* drop which is measured in a comparison voltmeter. The high-voltage supply of the photomultiplier is adjusted to give a constant *IR* drop with the attenuated direct light on the photomultiplier, so as to compensate for changes in the photomultiplier sensitivity and largely offset changes in the lamp brightness. If the scattering due to the air is maintained constant, the lower limit of measurement can be reduced to the background noise, which is about 1·5% of the air scattering. This corresponds to the light scattered by a sample containing about 3×10^{-11} g/l of a dioctyl phthalate aerosol of 0·3 μ diameter. Since the instrument is sensitive to the molecular scattering due to gases, they may provide a convenient scattering standard for aerosol measurements, which can then be expressed as the ratio of the light scattering of the aerosol to that of the standard gas. Since gases vary widely in their light-scattering ability, such measurements also would find application in gas analysis. A.

535.434

4569. Light scattering in silver sols. S. R. Sivarajan. *J. Indian Inst. Sci. A*, **37**, *No.* 1, 14–17 (*Jan.*, 1955).

The intensity of the transversely scattered light has been measured at different wavelengths for six typical silver sols using a photomultiplier. Applying Gans's theory for small ellipsoidal particles in metallic sols, the intensities of scattering have been calculated for different axial ratios B/A of a small prolate ellipsoid of silver and compared with the experimental data. The relative sizes as well as the degree of departure from spherical shape for the particles present in the different sols have been estimated. A comparison has also been made between the absorption and intensities of scattering at different wavelengths. A.

535.434 : 548.5

4570. Light scattering from crystallizing polymers. F. P. Price. Note in *J. phys. Chem.*, **59**, *No.* 2, 191–2 (*Feb.*, 1955).

The change in dissymmetry observed during crystallization indicated a progressive decrease in r.m.s. particle size. An explanation is suggested.

A. R. STOKES

535.435

4571. On a new case of molecular diffraction of light observed during the dissolution of two illimitably miscible liquids. P. Simova. *Izv. Bulg. Akad. Nauk.*, **3**, 3–12 (1952; publ. 1954) In Bulgarian. Summaries (1 *p.*) in Russian and (1 *p.*) in German.

The causes of the occurrence of intense molecular diffraction of light during the dissolution of the liquids were investigated on 50% and 30% aqueous solutions of chemically pure formic acid. After vacuum distillation of the solution ordinary Raman spectra of the solution are obtained during the cooling process at 10–15°c. If, however, the vessel containing the solution is cooled sharply during the distillation process by solid carbon dioxide so that the distillate is instantly solidified, an intense diffraction lasting many hours and producing continuous blackening is observed. This intense diffraction stops after a certain period and ordinary Raman spectra are obtained again. However, the intense diffraction effect may be obtained any number of times by repeating the distillation procedure described. This phenomenon is not fluorescence caused by impurities, but seems to be a case of classical molecular diffraction. Its temperature dependence and the dependence of the diffraction intensity on the time elapsed after solidification of the solution were also investigated. The phenomenon must be due to the phase structure of the solution solidification and the kinetics of the dissolution process.

B. F. KRAUS

535.51

4572. On the optical behaviour of crypto-crystalline quartz. C. V. Raman and A. Jayaraman. *Proc. Indian Acad. Sci. A*, **41**, *No.* 1, 1–6 (*Jan.*, 1955).

The polarization of the light regularly transmitted by fibrous chalcedony and the character of the diffraction spectra exhibited by iridescent agate are described and discussed. It is shown that the phenomena point conclusively to the laminations in iridescent agate responsible for the diffraction effects being a consequence of the periodic orientation of the *c*-axis of quartz along the length of the fibres. Photographs illustrative of the optical effects and of the X-ray diffraction patterns of the materials are reproduced. A.

535.515

4573. Further investigations on the bi-refracting filter. I. Šolc. *Czech. J. Phys.*, **5**, *No.*1, 80–6 (*Feb.*, 1955) In Russian.

Deals in greater detail with work reported in Abstr. 7349 (1954). For the optimal angle ε, which is included by the principal directions of the consecutive plates, a simple relation has been found, i.e. the angle ε depends only on the number of plates which the filter contains. This relation holds for filters of the first and second modification. The question of tolerances during production of the filter is also dealt with in detail. The quality of the filter depends on the purity and homogeneity of the material. The angle of cut must be kept within an accuracy of about 10′—30′, the thickness and parallelism of the optical flats after polishing must be measured interferometrically. Otherwise the difficulties in producing the filter do not exceed those encountered in the production of conventional optical products. The original assertion about the use of oblique cuts for the production of filters had to be

corrected; only cuts parallel to the optical axis of the crystal can be used, a fact accounted for by the propagation of light in crystals. The possibility of tuning the filter by varying the inclination is also studied in detail. There are two possible perpendicular directions, given by the centre-lines of the principal directions of the plates. The use of these two directions permits the tuning of the filter between very wide limits both in the direction of shorter as well as longer wavelengths. The shift of the passband as a function of the angle of inclination can be approximately described by an equation the validity of which is also proved by a diagram. After introducing simplifying assumptions a relation for the maximally permissible convergence of the light is derived. A.

535.515 : 548.24

4574. Optical study of $PbZrO_3$ and $NaNbO_3$ single crystals. F. Jona, G. Shirane and R. Pepinsky. *Phys. Rev.*, **97**, *No.* 6, 1584–90 (*March* 15, 1955).

The twinning of the antiferroelectric crystals $PbZrO_3$ and $NaNbO_3$ has been studied. Essential differences between this twinning and the domain structure of ferroelectric $BaTiO_3$ have been observed. It is shown that both orthorhombic $PbZrO_3$ and $NaNbO_3$ are optically negative and the refractive index is smallest along the *a* axis, along which axis the main antiparallel ion shifts have been reported. The birefringence of the crystals has been measured as a function of the temperature up to the transition points, and compared with the temperature dependence of the spontaneous strain. A.

535.55

4575. Some optical considerations in the design of a polariscope and in photoelastic stress analysis. V. Cadambe and R. K. Kaul. *J. sci. industr. Res.*, **14B**, *No.* 2, 41–50 (*Feb.*, 1955).

The design of a polariscope incorporating features essential for the reproduction of fine fringe patterns in homogeneous stress fields, and also in non-homogeneous fields, including regions of high-stress gradients, is described. The method of counting fringe orders accurately and the design of a photometer and its use are described. Correction factors necessary for taking into account various errors due to small obliquity of incident rays and optical unbalance are indicated. A.

535.65 : 535.68

4576. Colours by lamplight. C. Roy-Pochon. *Bull. Soc. Franç. Elect.*, **5**, 109–19 (*Feb.*, 1955) In French.

The first half of the paper describes the basic principles of colour specification, with particular reference to the C.I.E. system, and shows that colour specification of a light is no criterion of its colour-rendering properties. In the second half the author describes the spectral band methods of specifying colour rendering. In particular she proposes the use of four pairs of "complementary bands," a criterion of good colour rendering being the closeness with which the ratios of the energies in each pair of complementaries are equal for the lights being compared. J. W. T. WALSH

535.7

Physiological optics. Vision. *See under* "Medical science. Human physiology." Decimal classification 612.84

535.82

4577. Microscopy in the infrared. G. Nomarski. *Rev. Opt.*, **34**, *No.* 1, 29–41 (*Jan.*, 1955) In French.

A review article covering techniques and equipment. Subjects dealt with include objectives both refracting and reflecting, image convertors, solid conducting cells, microphotometry, interference microscopy, infrared sources and filters. 20 references are given. R. W. FISH

535.822.9 : 535.33.07

4578. A mirror microscope. F. Dourneau. *Rev. Opt.*, **34**, *No.* 1, 43–4 (*Jan.*, 1955) In French.

A microscope attachment to a spectrophotometer is described. It works in the infrared region and consists basically of a condenser and objective system, each containing two mirrors. Additional mirrors allow the optical path to be bent to suit the existing spectrophotometer. R. W. FISH

535.825

4579. A visual attachment for a microscope using infrared illumination. S. Lowenthal. *Rev. Opt.*, **34**, *No.* 1, 41–3 (*Jan.*, 1955) In French.

An image convertor is used to give a visual image at an overall magnification of 250×, with a working wavelength of 1 μ. Practical details of the attachment are given and it is said to be of general application. R. W. FISH

535.834

4580. A practical criterion of the twilight performance of field glasses. H. Köhler. *Optik*, **12**, *No.* 2, 71–84 (1955) In German.

Previous theories of the performance of field glasses show some disagreement on the rôle of the magnification. An experiment is described which proves that, at the lower light levels, the theory of Kuhl is correct and the performance depends upon the square root of the magnification. At higher light levels, there are departures from this theory. R. W. FISH

535.89

4581. The reach of narrow beam searchlights. L. Foitzik. *Optik*, **12**, *No.* 2, 85–93 (1955) In German.

The target visibility is defined in terms of the searchlight parameters, the target distance and reflectance, the scattering in the air, etc. Details of some practical tests carried out on the visibility of target balloons are given and compared with the theoretical results. R. W. FISH

535.89

4582. Electronic flicker apparatus with automatic frequency variation. C. Berger, A. Mahneke and O. Mortensen. *J. Opt. Soc. Amer.*, **45**, *No.* 4, 307–8 (*April*, 1955).

An electronic apparatus is described which delivers light flashes with intensity, light-dark ratio and frequency as independent variables. The flash rate is varied automatically, and is proportional to the voltage on the control grid of the charging pentode. The control voltage is taken from a highly isolated

condenser through a cathode follower with very low grid current. When the condenser is charged or discharged by a constant current, the control voltage, and hence the frequency, will change proportionally with time. The rate of frequency-change is determined by the magnitude of the current, and can be started or reversed either manually or by a saw-tooth voltage. This automatic and variable frequency variation makes it possible to keep the conditions more constant from measurement to measurement for each rate of frequency change, and to compare the effect of varying speed of frequency variation as well as of the duration of series of exposures (prethreshold exposure time) upon FFF (flicker fusion frequency) with significant precision. These factors are important for the standardization of FFF determinations. A.

535.89 : 534.42

4583. Wave synthesizing light chopper. W. WALLIN. *J. Opt. Soc. Amer.*, **45**, *No.* 4, 287–92 (*April*, 1955).

A method is described for modulating light according to any function describable by Fourier series. Any such wave shape can be synthesized although the mean light level cannot in general be controlled. Polar equations are developed for apertures that can be used in conjunction with rotating shutters having radial edged sectors left open, the combination generating $\sin n\theta$. Of particular interest are cases in which the aperture is restricted to any desired zone of the aperture disk. Synthesis is then accomplished by constructing a disk of several zones, each being used for a particular harmonic. A.

HEAT 536

536.083

4584. An apparatus for measuring the thermal conductivity of metals in vacuum at high temperatures. M. Moss. *Rev. sci. Instrum.*, **26**, *No.* 3, 276–80 (*March*, 1955).

The method consists, essentially, of measuring both the axial temperature gradient and the transfer of heat under steady state conditions in a thermally shielded cylindrical rod of the metal which is heated at one end and cooled at the other. The objective was to make precise determinations of conductivity without reliance on previously established data for standard metals. In certain respects the apparatus embodies simplification of, and improvement over, other equipment of this type. A calorimetric measurement of heat flow constitutes a distinct advantage of the instrument both as to its simplicity and the fact that it supplies the data necessary for a direct rather than a comparative evaluation of thermal conductivity. Other features include vacuum operation and special instrumentation to facilitate the measurement of temperature differences. Tests have been made on nickel, zirconium, and a zirconium-3% tin alloy from room temperature up to the range between 500 and 700°C. Where comparison is possible the results are in close agreement with some of the most accurate published data of this type. A.

536.2.01

4585. The symmetry relations for anisotropic heat conduction. S. H. CRANDALL. *Physica*, **21**, *No.* 3, 251–2 (*March*, 1955).

Shows that for a finite bounded conductor the Onsager reciprocity relation implies the symmetry of the thermal conductivity tensor. E. P. WOHLFARTH

536.2.02

4586. The solution of transient heat flow and heat transfer problems by relaxation. G. LIEBMANN. *Brit. J. appl. Phys.*, **6**, *No.* 4, 129–35 (*April*, 1955).

It is shown that by choosing a suitable finite difference approximation, parabolic partial differential equations, e.g. the heat conduction equation, can be converted into a series of boundary value problems of the Poisson type, each with specified boundary conditions, which can be easily solved by Southwell's relaxation technique. The method is first discussed with reference to the one-dimensional case, and is then generalized to problems in (x, y)- and (r, z)-co-ordinates. Heat transfer problems can be brought within the scope of the method. The outstanding characteristic of the method is the very stable nature of the solution for all values of the time interval; this permits the choice of relatively great time intervals, so that a complete solution, extending over a long period of time, may be obtained in a small number of steps without loss of accuracy. The required relaxation patterns are given and several numerical examples are included. A.

536.24

4587. A problem of heat transfer in laminar flow between parallel plates. J. SCHENK. Letter in *Appl. sci. Res. A*, **5**, *No.* 2–3, 241–4 (1955).

A numerical solution is given for the Mulder problem of heat flow between two parallel plates, one having infinite thermal resistance [Abstr. 5526 (1954)]. The treatment is as for the Purday problem, where the plates have equal thermal properties, and as for the Graetz problem considering tubes [Abstr. 8682 (1951); 5526 (1954)]. The eigenfunctions Xn of the general solution are calculated for three values of the outside Nusselt number Nu_0. The entry length is $0{\cdot}21\ PéD$, against $0{\cdot}06\ PéD$ for the other two problems; the inside number Nu_i as a function of Nu_0 shows the same trend. Some general conclusions are drawn for the case of the two plates having different transmissivities. J. J. PHIPPS

536.413

4588. Thermal expansion of nitrates of lead, barium and strontium. R. SRINIVASAN. *Proc. Indian Acad. Sci. A*, **41**, *No.* 2, 49–54 (*Feb.*, 1955).

This was studied above room temperatures. Lead nitrate decomposes rapidly beyond 200°C while crystals of barium nitrate crack above 270°C. Strontium nitrate exhibited no such phenomena till 550°C. These crystals are isomorphous. The expansion coefficients of lead and strontium nitrates are nearly equal; they also possess the same ionic radii. Barium nitrate has a considerably smaller expansion coefficient though its ionic radius is larger than for the other two. This peculiar behaviour of barium nitrate indicates a stronger binding in this crystal—a fact which is supported by measurements on the elastic constants, Raman effect, solubilities of these salts and a study

of the magneto-optic anomaly of aqueous solutions of these salts. A.

536.421.1

4589. Viscous flow in melts of "rigid anisotropic" molecules. A. A. K. Al-Mahdi and A. R. Ubbelohde. *Trans Faraday Soc.*, **51**, *Pt* 3, 361–8 (*March*, 1955).

Viscous flow has been studied in melts of phenanthrene, acenaphthene and 2 : 3- and 2 : 6-dimethyl naphthalenes over a range of temperature. As the freezing points are approached, melts of the last three hydrocarbons show marked departures from linearity, in plots of log η against $1/T$, where η is the viscosity and T the absolute temperature. Plots of fluidity $1/\eta$ against specific volume $1/\rho$ also show some departure from linearity in certain cases on approaching the freezing point. A probable interpretation is that the mechanism of flow becomes modified due to the formation of larger and more interlocking cybotactic clusters of molecules on approaching the freezing point. Further measurements of volume changes on melting of crystals containing rigid aromatic molecules have revealed additional examples in which there is no onset of "rotation" on melting. A.

536.421.4

4590. The freezing of supercooled water. S. C. Mossop. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 4, 193–208 (*April*, 1955).

To investigate the freezing of supercooled water of high purity, measurements were made of the freezing point of samples of water in glass capillary tubes, both with and without a hydrophobic coating on the walls. These showed the difficulty of excluding freezing nuclei that originate in room air. A simple technique was therefore devised for preparing uncontaminated specimens of water in glass or fused silica tubes. Samples prepared in this way froze at temperatures consistently lower than any previously recorded for similar volumes of water. The lowest value obtained for water in glass was $-34{\cdot}5$°C for a volume of 6×10^{-4}cm^3. It is shown that some of the results of previous workers can be accounted for by the presence of foreign freezing nuclei in the water used. The relationship between volume and freezing point for spontaneous nucleation is discussed in the light of experimental results. A.

536.423.1

4591. Rectification of ideal ternary mixtures, the resistance of the exchange of matter being assumed to be offered only in the liquid phase. E. A. Rische. *Z. angew. Phys.*, **7**, *No.* 2, 90–6 (1955) In German.

Supplements Hausen's theory of rectification [Abstr. 6151 (1952)], which deals with the case when the resistance of matter exchange is assumed to exist in the vapour phase only. Identical diagrams are obtained for both extreme cases. Solutions of similarly constructed differential equations differ only in the value of one exponent. The course of rectification agrees well with the numerical value of the solution if the exponent used is the geometric mean of exponents for the two extreme cases. F. LACHMAN

536.48

4592. Influence of symmetry effects on the thermal excitations of liquid ^{3}He and ^{4}He. J. de Boer and E. G. D. Cohen. Letter in *Physica*, **21**, *No.* 1, 79–80 (*Jan.*, 1955).

Results based on de Boer's modified cell model [Abstr. 782 (1955)] are given. These are (*a*) collective excitations giving an entropy/volume $16\pi^5k^4T^3/45h^3c^3$, and (*b*) excitations of pairs of molecules in cell clusters. For these radial wave-functions in the 12–6 Lennard-Jones potential give energies of excited states $\varepsilon_l = k\Theta_r l(l+1)$ with $\Theta_r = 1{\cdot}13$°K for He^4 and $1{\cdot}25$°K for He^3. The necessary symmetrizations result in the disappearance of the odd levels in He^4 whereas they assume an extra weight 3 in He^3. This gives entropies and susceptibilities of the observed order of magnitude without introducing any adjustable parameters. Co-operative phenomena so far not considered are expected to give even better agreement and may possibly lead to a λ-point for He^3 below $0{\cdot}4$°K. See also abstract following. H. LONDON

536.48

4593. Treatment of liquid He^3 based on the "cell" model. H. N. V. Temperley. Letter in *Phys. Rev.*, **97**, *No.* 3, 835–6 (*Feb.* 1, 1955).

A simple liquid model consisting of a scheme of discrete energy levels (an octet at $2{\cdot}7°$ and a triplet at $0{\cdot}4°$ above the singlet ground level) assigned to a typical pair of neighbouring atoms together with a continuous Debye spectrum gives a surprisingly accurate representation of the thermodynamic functions and the magnetic susceptibility. The equations predict a transition at $0{\cdot}1$–$0{\cdot}2$°K to an antiferromagnetic state [see Abstr. 7376 (1954)]. H. LONDON

536.48

4594. Energy levels in liquid He^3. O. K. Rice. Letter in *Phys. Rev.*, **97**, *No.* 4, 1176 (*Feb.* 15, 1955).

The hindered rotation of pairs of He^3 atoms previously discussed [Abstr. 1776 (1955)] leads to a degeneracy of 3 of the first excited level, instead of 9 for free rotation. Degeneracy of 3 has been postulated in order to represent the experimentally observed susceptibility (see preceding abstract). H. LONDON

536.48

4595. Bulk formation of helium-II in capillaries. K. W. Taconis. Letter in *Phys. Rev.*, **97**, *No.* 4, 1176–7 (*Feb.* 15, 1955).

It has been observed [Abstr. 11013 (1954)] that a capillary fills itself to the normal capillary height h_m even if its lower end does not reach the bath level but is in film contact with it. This is shown to be due to the inner curvature of the tube, which causes a decrease in surface energy if the thickness of the film increases. The resulting maximum height of the lower end is $\frac{1}{2}h_m$. H. LONDON

536.48

4596. Kinetic theory of liquid helium. P. G. Klemens. Letter in *Phys. Rev.*, **97**, *No.* 4, 1181–2 (*Feb.* 15, 1955).

If one considers a condensed Bose–Einstein gas which has just changed the bulk velocity of its high states, so that the condensed state is not the ground state, and treats the interactions as binary collisions, then one can show that the only processes of importance are those in which a low-energy and a high-

energy particle combine to form another such pair. In this way momentum is transferred from the low to the high states. The relaxation time for this is $\tau \sim 3(|v_s - v_n|)^{-3}$ sec (if v is expressed in cm/sec). This is similar to Gorter and Mellink's $\tau \sim (50\rho_n)^{-1}(|V_n - V_s|)^{-2}$ sec and agrees somewhat better with flow experiments through wide channels. H. LONDON

536.48

4597. Adiabatic oscillations in liquid helium II. F. D. MANCHESTER. Letter in *Canad. J. Phys.*, **33**, *No.* 3–4, 146–7 (*March–April*, 1955).

These were produced in a thermally insulated tube, which communicates with the He II bath through a gap $\sim 10^{-4}$ cm wide, by suddenly changing the level or the temperature of the liquid in the tube in relation to that of the bath. Frequencies of the order of magnitude predicted by J. E. Robinson [Abstr. 6175 (1951)] were observed. H. LONDON

536.48

4598. Coefficient of expansion of liquid helium II. K. R. ATKINS AND M. H. EDWARDS. *Phys. Rev.*, **97**, *No.* 6, 1429–34 (*March* 15, 1955).

The coefficient of thermal expansion of liquid helium II was measured from the λ-point down to 0·85°K. Near the λ-point the coefficient varies very rapidly with temperature and may tend to minus infinity at the λ-point. The coefficient becomes positive below 1·15°K. The results are discussed in relation to Landau's theory and a value for $(\rho/\Delta)(\partial\Delta/\partial\rho)$ deduced. A.

536.48 : 534.21

4599. Ultrasonic propagation in magnetically cooled helium. C. E. CHASE AND M. A. HERLIN. *Phys. Rev.*, **97**, *No.* 6, 1447–52 (*March* 15, 1955).

Measurements have been made of the velocity and attenuation of ordinary sound in liquid helium at a frequency of 12·1 Mc/s, over the temperature range from 1°K down to 0·1°K. The velocity is essentially independent of temperature and has the value 240 ± 5 m/sec. The attenuation passes through two closely spaced maxima near 0·9°K and then falls smoothly to zero as the absolute zero is approached. These results agree qualitatively with the theoretical predictions of Khalatnikov. A.

536.48 : 537.312.62 : 532.6

Capillary waves in He II. *See Abstr.* 4409

536.48 : 541.183

4600. Adsorption of mixtures of He^3 and He^4. M. G. INGHRAM, E. LONG AND L. MEYER. *Phys. Rev.*, **97**, *No.* 6, 1453–6 (*March* 15, 1955).

The distribution of He^3 between the vapour phase and dilute mixtures of He^3 in He^4 adsorbed on jewellers' rouge (Fe_2O_3) has been measured between 1·6°K and 2·3°K, for saturations in the range 15% to 99%, corresponding to film thicknesses of 1·3 to 34 layers. The ratio of the mole fraction of He^3 in the vapour phase to that in the adsorbed phase is practically independent of the thickness of the adsorbed film and essentially the same as for the bulk liquid case. The onset of superfluidity in the adsorbed films does not influence the He^3 concentration in samples taken by simple desorption techniques. A.

536.48

4601. Superfluidity of unsaturated helium films above the λ temperature. E. LONG AND L. MEYER. Letter in *Phys. Rev.*, **97**, *No.* 6, 1717 (*March* 15, 1955).

This was demonstrated up to 2×10^{-3} deg above the bulk fluid λ-point by thermal conductivity measurements in nearly saturated films of an estimated thickness of 30–50 layers. H. LONDON

536.511 : 536.48

4602. Apparatus for reproducing the boiling point of hydrogen. A. S. BOROVIK-ROMANOV, M. P. ORLOVA AND P. G. STRELKOV. *Zh. tekh. Fiz.*, **24**, *No.* 7, 1219–23 (1954) In Russian.

The method described was used in the measurement of the boiling point of H [Abstr. 7233 (1952)]. The reproducibility of the datum-point temperature (equilibrium between the liquid and vapour phase) can only be attained if the effect of the ortho-H/para-H conversion is either eliminated or allowed for. The apparatus includes 2 condensation thermometers in one of which the composition of H is maintained by means of a catalyst in a state of equilibrium corresponding to room temperature, whereas in the other the equilibrium corresponding to ~20°K is established. The pressure differences between these thermometers indicate the degree of ortho-para conversion. Comparison with the results of the National Bureau of Standards and the Laboratory of Leyden shows that the systematic temperature difference is of the order of 0·001–0·002 deg. Systematic measurements of the boiling point with the aid of a reliable Pt resistance thermometer showed that, with a probability of 90%, the measurement of the boiling point of H, carried out by means of the apparatus described, is accurate within ±0·003%. F. LACHMAN

536.521

4603. The accuracy of radiation pyrometers. J. EULER. *Z. angew. Phys.*, **7**, *No.* 2, 86–90 (1955) In German.

The effect on accuracy of the observer's eye, the size of the source and other factors are considered in terms of reciprocal temperature scales in the range 700°–3 200°C. E. H. DOCK

536.581.1

4604. An isothermal bath for use in the temperature range 200–500°C. W. H. BRIDGES, J. V. CATHCART AND G. P. SMITH. *J. sci. Instrum.*, **32**, *No.* 4, 139–40 (*April*, 1955).

A constant-temperature bath having excellent control and stability characteristics has been constructed. A molten 50–50 wt% mixture of sodium nitrate and sodium nitrite, vigorously stirred, was used as the bath liquid. An electronically-balanced Wheatstone bridge, operated in conjunction with a platinum resistance thermometer, controlled the bath temperature; a second resistance thermometer served to monitor the temperature. Temperature fluctuations of ±0·025 deg at 400°C were observed over a period of 500 hr, but control to ±0·01 deg could be attained for shorter periods of time. A.

536.581.3

4605. A variable-temperature cryostat. A. Johannin-Gilles and P. Johannin. Letter in *J. Phys. Radium*, **16**, *No.* 2, 162–3 (*Feb.*, 1955) In French.

The cryostat works over the range 15° to −35°c and was designed for the study of vapours spectrographically and for the measurement of vapour pressure. The apparatus is based on the principle of balancing electric heating against cooling by liquid nitrogen and the temperature is controlled electronically [see Abstr. 3305 B (1950); *Rev. gén. Elect.*, **59**, 175–8 (*April*, 1950)]. E. H. DOCK

536.62 : 536.48

4606. Preliminary experiments on the temperature-wave method of measuring specific heats of metals at low temperatures. D. H. Howling, E. Mendoza and J. E. Zimmerman. *Proc. Roy. Soc. A*, **229**, 86–109 (*April* 5, 1955).

The apparatus consists basically of a rod of the metal, one end of which is in thermal contact with a bath while at intervals along the rod are a heater and two thermometers. Two quantities are measured: the first is the velocity of propagation down the rod of temperature waves of known frequency generated by an alternating current in the heater; the second is the temperature gradient down the rod produced by a steady current in the heater. These measurements allow respectively the thermal diffusivity D and the thermal conductivity k to be derived; the ratio k/D is the specific heat of the rod per unit volume. The accuracy with which this ratio can be measured is comparable with that of the conventional static method of specific-heat measurements. The most important differences between the two methods of specific-heat measurements are that (i) the static method requires the specimen to be carefully isolated from its surroundings, while in the temperature-wave method the specimen always remains in thermal contact with them, (ii) that the temperature-wave method uses much smaller specimens than the other, and (iii) that it is hoped that it will be applicable with little loss of accuracy down to the temperatures attainable by adiabatic demagnetization. The method was tried on copper and aluminium specimens in the liquid-helium temperature range, using frequencies between 16 and 1 800 c/s. The design of suitable thermometers and electronic circuits is described. Among other corrections, those due to the finite length of the specimens were investigated and are discussed in detail, and a method of detecting and eliminating differences of thermal time-lags through the thermometers is described. The method appears to give results which are free from systematic errors. A.

536.626.2

4607. An electrically calibrated bomb calorimeter. A. R. Challoner, H. A. Gundry and A. R. Meetham. *Phil. Trans A*, **247**, *No.* 936, 553–82 (1955).

After a review of the physical foundations of bomb calorimetry, a bomb calorimeter is described which can be heated electrically or by combustion. The evaporation of water is prevented by sealing the vessel completely. Other modifications in the normal technique are introduced after consideration of (*a*) the difference in temperature between the outer surface of the calorimeter and the thermometer immersed in it, (*b*) the effective "boundary" of the calorimeter in electrical and combustion experiments, and (*c*) variation with temperature of the constants of the apparatus. The heat of combustion of samples from a batch of thermochemical quality benzoic acid is found to be 26 436 J/g under "standard bomb conditions." The standard error of the determination, a combination of errors in reproducibility of electrical and combustion experiments and in measurement of the corrections, is estimated to be 2·2 J/g. A.

536.626.2

4608. Miniature bomb calorimeter for the determination of heats of combustion of samples of the order of 50 mg mass. W. S. McEwan and C. M. Anderson. *Rev. sci. Instrum.*, **26**, *No.* 3, 280–4 (*March*, 1955).

A new bomb calorimeter for the combustion of very small quantities of organic materials has been constructed. The use of a small sample size is particularly important when dealing with explosive materials which when used in larger quantities, may detonate enough to spatter material from the crucible or when using substances which are difficult to prepare and purify in larger amounts. This calorimeter has several unique design features including a light weight bomb, coaxial stirrer, and flame holding sample holder. A.

536.628.2 : 536.63 : 536.48

4609. An adiabatic calorimeter for the temperature region below 20°K. The specific heat of sodium chloride. J. A. Morrison, D. Patterson and J. S. Dugdale. *Canad. J. Chem.*, **33**, *No.* 2, 375–82 (*Feb.*, 1955).

A simple adiabatic calorimeter for specific heat measurements at very low temperatures is described. Liquid helium is made in the cryostat by the Simon expansion method. The calorimeter and adiabatic shield are cooled below 13°K by conduction of heat along the lead wires rather than by conduction with exchange gas. The working thermometer is a carbon resistor which has been calibrated against a helium gas thermometer. The assembly has been used to determine the specific heat of rock salt between 2·5° and 20°K. The results are compared with the theoretically derived values of the specific heat and Debye characteristic temperature for sodium chloride. A.

536.632 : 536.75

4610. The thermodynamic properties of nitrogen trifluoride from 12°K to its boiling point. The entropy from molecular and spectroscopic data. L. Pierce and E. L. Pace. *J. chem. Phys.*, **23**, *No.* 3, 551–5 (*March*, 1955).

The heat capacity of nitrogen trifluoride has been measured from 12° to 144°K. The heat of the transition at 56·62°K was found to be 361·8 cal/mole. The heat of fusion at the triple point temperature, 66·37°K, was found to be 95·1 cal/mole. The heat of vaporization at the normal boiling point, 144·15°K, was found to be 2 769 cal/mole. The vapour pressure has been measured, and the data are closely represented by the equation

$$\log_{10}P_{mm} = -673{\cdot}5\,828/T + 1{\cdot}869\,858\,\log_{10}T - 0{\cdot}00\,783\,355T + 4{\cdot}64\,615.$$

The entropy of nitrogen trifluoride gas has been calcu-

lated from the calorimetric data and the third law of thermodynamics to be 54·50 cal/deg.mole at 144·15°K. This value agrees very well with the value 54·61 calculated from spectroscopic data and structural parameters which include a pyramidal model for the molecule. A.

536.633 : 536.72

4611. Thermodynamic properties of argon in the temperature range −100 to +600°C and pressure range 0 to 80 atmospheres. E. WHALLEY. *Canad. J. Technol.*, **33**, *No.* 2, 111–16 (*March*, 1955).

The values of PV in the temperature range −100 to +600°C and specific heats, enthalpy, entropy and Joule–Thomson coefficient, in the temperature range 0 to 600°C, have been calculated for argon in the pressure range 0 to 80 atm. using the compressibility data presented in a previous paper [Abstr. 4250 (1954)]. A.

THERMODYNAMICS 536.7/.8

536.7

4612. Considerations regarding the expression for work in thermodynamics. J. MERCIER. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 6, 605–8 (*Feb.* 7, 1955) In French.

Expressions analogous to those obtained from writing dQ in terms of the changes in two state variables and the substitution $dQ = TdS$ are found by writing dW in terms of changes in the state variables and the substitution $dW = pdv$. The parallelism between Q and W and related coefficients is examined for several cases. F. E. HOARE

536.7

4613. Relativistic thermodynamics of irreversible processes. IV. Systems with polarization and magnetization in an electromagnetic field. G. A. KLUITENBERG AND S. R. DE GROOT. *Physica*, **21**, *No.* 3, 148–68 (*March*, 1955).

For Pt III, see Abstr. 6582 (1954). It is assumed that the medium is isotropic as far as polarization and magnetization are concerned. The relativistic second law of thermodynamics is derived for these systems. It appears that there is a connection between the explicit expression for the ponderomotive force and the form of the second law of thermodynamics. The entropy balance is deduced from the fundamental relativistic macroscopic laws. The phenomenological equations and the Onsager relations are given for anisotropic media. A.

536.7

4614. Relativistic thermodynamics of irreversible processes. V. The energy-momentum tensor of the macroscopic electro-magnetic field, the macroscopic forces acting on the matter and the first and second laws of thermodynamics. G. A. KLUITENBERG AND S. R. DE GROOT. *Physica*, **21**, *No.* 3, 169–92 (*March*, 1955).

A symmetric energy-momentum tensor for the macroscopic electromagnetic field in media which are isotropic as far as polarization and magnetization are concerned is derived from the general expressions, obtained in Pt IV, for the forces acting on the matter. The non-diagonal elements of this tensor are the same as those of Abraham's tensor. Explicit expressions are given for the macroscopic forces acting on the matter and for the first and second laws of thermodynamics. It is shown that Abraham's tensor leads to an equivalent formalism and that from the point of view of the developed theory this tensor is preferable to Minkowski's tensor. A.

536.7 : 530.145

Thermodynamics and quantum mechanics. *See Abstr.* 4388

536.7 : 539.501

4615. Variational principles in irreversible thermodynamics with application to viscoelasticity. M. A. BIOT. *Phys. Rev.*, **97**, *No.* 6, 1463–9 (*March* 15, 1955).

General differential equations are derived for the time history of a thermodynamic system undergoing irreversible transformations. This is done by using Onsager's principle, and introducing generalized concepts of free energy and thermodynamic potentials. From these equations it is shown that the instantaneous evolution of the system satisfies a principle of minimum rate of entropy production. It is also shown how Prigogine's theorem for the stationary state fits into the present theory. Another variational principle is established for the case where certain variables are ignored in analogy with the methods of virtual work in mechanics. This principle which applies to complex physical-chemical systems is developed more specifically for viscoelastic phenomena, and as an example the differential equations for the deflection of a viscoelastic plate is derived. A.

ELECTRICITY 537

ELECTROSTATICS . DIELECTRICS 537.2

537.21

4616. The magnitude of charge of conduction particles moving in an a.c. field. A. FURUYA, S. SEKIGUCHI AND Y. HAYASHI. *J. Inst. Elect. Engrs Japan*, **73**, *No.* 9, 984–9 (*Sept.*, 1953) In Japanese.

With regard to the separation of particles in an a.c. field, the magnitude of charge of the particle obtained by conduction from the lower plate is one of the most important conditions affecting the separation efficiency, yet this kind of charge has never been sufficiently discussed. With this in mind, the charge of a particle moving in the field was measured by means of a d.c. amplifying circuit of the type developed by L. A. Dubridge and H. Brown. H. G. M. SPRATT

537.213 : 621.3.013 : 621.319.4

4617. Slit diaphragm condensers. A contribution to the practice of calculation of potential fields. E. KREYSZIG. *Z. angew. Phys.*, **7**, *No.* 1, 13–17 (1955) In German.

The potential distribution in a parallel-plane condenser in which a third electrode lies eccentrically between the other two in the form of a slit diaphragm is calculated by conformal transformation methods. Good agreement is claimed between the calculated and experimentally determined values. C. G. MORGAN

537.226 : 621.315.61

4618. Dielectric materials and applications. Edited by A. R. VON HIPPEL. *Cambridge, Mass.: The Technology Press of M.I.T.; New York: John Wiley and Sons; London: Chapman and Hall* (1954) xii + 438 *pp.*

The book is written by twenty-two specialist contributors and aims at providing a textbook and reference work for the "research worker, development engineer, manufacturer, field engineer and actual user of nonmetals." Two introductory sections deal with the theoretical basis of dielectrics from the macroscopic and molecular standpoints. Techniques for the measurement of permittivity and permeability, microwave spectroscopy, and magnetic resonance are described, and dielectric materials of all kinds are discussed. The uses of dielectric materials, particularly in electronic equipment, are given, together with uses for particular dielectric materials for devices such as rectifiers, piezoelectric transducers and resonators, magnetic and dielectric amplifiers, and memory devices. The requirements of the U.S. armed forces are briefly recounted. Tables giving the dielectric properties of more than 600 materials in the frequency range from 10^2 to $2{\cdot}5\times10^{10}$ c/s and for temperatures up to 500°C are included. (There are about 400 diagrams and plates.) C. A. HOGARTH (R)

537.226

4619. On the polarization at high frequency of a spherical substance and of an ensemble of perfectly dielectric particles. A. COLOMBANI. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 5, 503–5 (*Jan.* 31, 1955) In French.

An expression is derived for the dipole moment of a small spherical granule immersed in a uniform periodic electric field of frequency f, the diameter of the granule being $\ll c/f$. R. A. NEWING

537.226.1

4620. The dielectric constant of a plasma in a steady magnetic field. M. E. GERTSENSHTEIN. *Zh. éksper. teor. Fiz.*, **27,** *No.* 2(8), 180–8 (1954) In Russian.

The tensor of the complex dielectric constant of the electron gas is calculated, considering the thermal movement of the electrons. It is shown that in a co-ordinate system moving with the electron the field of a monochromatic planar wave is frequency-modulated, as a result of which resonance effects will occur in the higher harmonics. The author analyses critically the suggested existence of gaps in the oscillation spectrum of a plasma at frequencies which are multiples of the hydromagnetic frequency and establishes the conditions to be satisfied. It is found that the two necessary conditions cannot be satisfied simultaneously in the case of radiowaves, and hardly ever in the case of plasma waves (these being the two electrodynamic types of oscillations possible in a plasma). The spectrum of radio-waves must therefore be free of gaps. The conditions for resonance phenomena are much more favourable in the case of acoustic waves in a heavy molecular ionized gas, the phase velocity of which may coincide with the velocity of sound in such a gas, i.e. is of the order of the thermal velocity of the gas molecules. B. F. KRAUS

537.226.1

4621. Extension of Fröhlich's general theory of the static dielectric constant to dielectrically anisotropic materials. J. G. POWLES. *Trans Faraday Soc.*, **51,** *Pt* 3, 377–82 (*March*, 1955).

The more detailed information can be obtained with little extra labour in the event of the approximate isotropic calculation being practicable. In illustration of the use of the general formula the anisotropy of the dielectric constant of some particular anisotropic materials is discussed. It is pointed out that for anisotropic dielectrics no general formulae connecting the dielectric constant to molecular quantities can be obtained with any physically plausible assumptions. The anisotropy of the dielectric constant is intimately related to the crystal structure and a separate calculation for each material is necessary. A.

537.226.1 : 541.182.43

The electrical conductivity and permittivity of mixtures, with special reference to emulsions of water in fuel oil. *See Abstr.* 5052

537.226.1.08

4622. Measurement of the complex permeability of carbonyl iron powders at 4000 Mc/s. A. NISHIOKA AND H. OKAMOTO. Note in *J. Phys. Soc. Japan*, **10,** *No.* 1, 79 (*Jan.*, 1955).

Four grades of powder, of average particle diameters ranging from 5 to 20 microns, were dispersed in polystyrol and measured by the open and short-circuit standing-wave method. Extrapolation of the results to 100% concentration (using J. B. Birks's empirical formula) gives permeabilities ranging from 23 to 12 respectively, with loss tangents of 1·4–1·5. F. F. ROBERTS

537.226.1.08 : 541.183

An apparatus for the measurement of dielectric constants of adsorbed gases at frequencies up to 100 Mc./sec. *See Abstr.* 5061

537.226.2/.3

4623. The structure of high-polymer–plasticizer systems in the light of dielectric measurements and their statistical analysis. G. GEPPERT. *S.B. Dtsch. Akad. Wiss. Berlin, Kl. tech. Wiss.*, **1953,** *No.* 1, 56 *pp.*, publ. 1954. In German.

Measurements of the dielectric constant and dielectric loss at 800 c/s and of the d.c. resistance of polymer–plasticizer systems (PVC, benzyl cellulose and nitrocellulose and various plasticizers) of varying plasticizer content at temperatures in the region of the "freezing point" (−20 to 120°C) show sharp changes of slope in the resistance-temperature curves at points corresponding to maxima in the loss curves and points of inflection in the dielectric constant curves. From a statistical analysis of the curves deductions are made about the kind of polymer-plasticizer interaction. P. CUCKA

537.226.2

4624. The dielectric properties of acenaphthylene styrene copolymers. J. V. L. PARRY. *Rep. Brit. Elect. Res. Assoc., Rep.* L/T286, 4 *pp.* (1952).

537.226.2

4625. The refractive index of water and water solutions of sodium sulphate in the region of metre waves. I. S. FROLOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 4(10), 477–86 (1954) In Russian.

Using Drude's first method the results at 430 cm for H_2O are given by $n_{17°} = 9{\cdot}003\ (\pm 0{\cdot}018) + 0{\cdot}0207\ (T - 17)$. For Na_2SO_4 solutions the accuracy is impaired by the increased conductivity but measurements remain possible up to 0·01 N for which strength $n_{17°} = 9{\cdot}72$. D. H. WHIFFEN

537.226.2 : 534.22/.23

Permittivity and mechanical loss in long chain polymers. *See Abstr.* 4447

537.226.2 : 536.424.1

4626. Study of the dielectric behaviour of solid cyclohexanone. L. REINISCH. *C.R. Acad. Sci. [Paris]* **240**, *No.* 10, 1077–8 (*March* 7, 1955) In French.

With pure cyclohexanone there is a sharp transition point at −48·3°C, above which ε' is ∼15 and below ∼3 although both regions show some dispersion.

D. H. WHIFFEN

537.226.2 : 539.133

4627. On some physical properties of methyl siloxanes. M. JOERGES-HEYDEN, H. G. MARKGRAF, A. NIKURADSE AND R. ULBRICH. *Z. Naturforsch.*, **10a**, *No.* 1, 10–21 (*Jan.*, 1955) In German.

Volume changes on mixing, and dielectric constants of mixtures of methyl siloxanes and chlorinated hydrocarbons were measured. The results can be explained on the assumption that the siloxane molecules are large, easily polarizable and have a small dipole moment. The work of Baker, Barry and Hunter [*Industrial and Engineering Chemistry*, **38**, 1117 (1946)] is criticized. The reduced Kirkwood parameter is shown to be in better agreement with experiment if allowance is made for molecular volume. Raman spectra show differences between mixtures of ethers and chlorinated hydrocarbons, and mixtures of methyl siloxanes and chlorinated hydrocarbons. The Kirkwood parameters also show these differences which do not appear to be due to steric hindrance by methyl groups. There are similarities, however, between the two systems in the way the breakdown voltage changes with number of breakdowns.

P. CUCKA

537.226.3 : 541.183.25

4628. The dielectric method, a new procedure for the study of water adsorption. J. LE BOT AND S. LE MONTAGNER. Letter in *J. Phys. Radium*, **16**, *No.* 2, 163–4 (*Feb.*, 1955) In French.

With water on various substrate samples of alumina and silica gel it is shown that in each case the temperature of the Debye maximum of dielectric loss is proportional to the vapour pressure relative to the saturation pressure. There are two separate lines for each gel with a change of slope at just the relative vapour pressure which is indicated by the Brunauer–Emmett–Teller isotherm to correspond to a complete monolayer. D. H. WHIFFEN

537.226.31 : 539.133

Dielectric absorption in phenols with intramolecular H bonds. *See Abstr.* 4859

537.226.32

4629. Temperature-relation of variations of the polarization of photo-electrets. G. NADZHAKOV AND N. T. KASHUKEEV. *Izv. Bulg. Akad. Nauk.*, **3**, 103–15 (1952; publ. 1954) In Bulgarian. Summaries (100 words) in Russian and German.

Investigations on the variations of the photo-polarization due to temperature variations of photo-electrets are presented. It was found that the main causes of these variations are a decrease of the photo-polarizability and an increase of the recombination of the space charges of opposite sign, and also an increase of the diffusion of the charges of photo-polarization in the direction of the electrodes. At low temperatures both processes occur at a very slow rate and the polarization either remains practically unchanged or decreases very slowly.

B. F. KRAUS

537.226.33

4630. On the analysis of dielectric relaxation measurements. R. H. COLE. *J. chem. Phys.*, **23**, *No.* 3, 493–9 (*March*, 1955).

Convenient methods of analysing dielectric dispersion and loss data satisfying the Debye equations are described and illustrated. The similarities and differences of the Fuoss–Kirkwood and circular arc representations of symmetrical, non-Debye-type dispersions are considered. Interpretations given by various writers to the asymmetric dispersion found by D. W. Davidson and the writer for glycols are discussed. Finally, the possibilities and limitations of reduced representations of dielectric measurements are examined. A.

537.226.8

4631. Spontaneous polarization of KH_2PO_4 and KD_2PO_4 crystals versus temperature. J. PIRENNE. *Physica*, **21**, *No.* 3, 219–22 (*March*, 1955).

The molecular field treatment of ferroelectricity discussed previously [Abstr. 2442 (1950)] is extended by including a term proportional to the fourth as well as a term proportional to the second power of the spontaneous polarization P in the potential energy expression. As a result the calculated P, T curves agree much better with the experimental curves and exhibit an isotope effect, as observed. The P^4 term is thought to arise due to elastic deformations and lattice distortions accompanying spontaneous polarization. [The analogous problem in ferromagnetism had been discussed earlier; see Abstr. 3426, 8523 (1953).] E. P. WOHLFARTH

537.228.1 : 531.781

Piezoelectric force measurement. *See Abstr.* 4398

537.228.1 : 534.133 : 621.372.412

4632. The *Q*-factor of quartz in parallel resonance. G. BRUNNER AND A. LÖSCHE. *Z. angew. Phys.*, **7**, *No.* 2, 67–71 (1955) In German.

The theory of the way a quartz crystal behaves when the frequency of the driver current varies linearly with time is developed and confirmed by experimental observation. It is possible to calculate the Q-factor from the experimental data.

J. M. HOUGH

537.228.1 : 621.372.412 : 621.317.337

4633. Application of frequency modulation to the determination of the quality, Q, of piezoelectric crystals. H. MAYER. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 6, 612–14 (*Feb.* 7, 1955) In French.

A brief description of a circuit for determining the natural oscillation frequency and the Q-factor of piezoelectric crystals of various shapes and sizes.

J. H. MASON

537.228.1 : 621.373.52 : 621.372.412

4634. Calculation of the frequency of oscillation of a quartz [vibrator] maintained by a transistor. G. BRIFFOD. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 8, 841–2 (*Feb.* 21, 1955) In French.

Brief calculation of the effect of the maintaining circuit.

W. BARDSLEY

ELECTRIC CONDUCTION . CURRENTS 537.3

537.311.1

4635. The Boltzmann equation for metals in strong fields. V. P. SHABANSKIĬ. *Zh. éksper. teor. Fiz.*, **27,** *No.* 2(8), 142–6 (1954) In Russian.

This is solved by expansion of the collision operator in powers of the parameter $\Delta p/p$, where Δp is the change in the modulus of the momentum p of an electron scattered by the lattice.

J. M. RADCLIFFE

537.311.1

4636. On deviations from Ohm's law in metals. V. P. SHABANSKIĬ. *Zh. éksper. teor. Fiz.*, **27,** *No.* 2(8), 147–55 (1954) In Russian.

Theoretical. On the basis of a theory developed in a previous paper (preceding abstract) it is shown that these deviations arise from the delay in the transfer of energy from the electrons to the lattice when the applied field is strong. In the limiting case of Boltzmann statistics the current is proportional to the square root of the field for high field strengths. At sufficiently low temperatures the resistance of metals, for a given current density, passes through a minimum.

J. M. RADCLIFFE

537.311.1

4637. Thermalization of positrons in metals. G. E. LEE-WHITING. *Phys. Rev.*, **97,** *No.* 6, 1557–8 (*March* 15, 1955).

It is shown that a thermalization time of 3×10^{-12} sec follows from the assumption that the interaction between a positron and a conduction electron can be approximated by an exponentially screened Coulomb potential.

A.

537.311.31 : 537.323

4638. Electrical conductivity and thermal E.M.F. of white tin. P. R. KAMADZHIEV. *Czech. J. Phys.*, **5,** *No.* 1, 60–3 (*Feb.*, 1955) In Russian.

Electrical conductivity and thermoelectric power as a function of temperature was measured on samples of the grey modification of tin composed of fine white grains compressed in a suitable form during the transformation from the white to the grey modifications. The results of orientational measurements and their evaluation are reported.

A.

537.311.31 : 539.23

4639. Resistance measurements on thin films of tin. S. TUNAKAN. *Rev. Fac. Sci. Univ. Istanbul C,* **19,** *No.* 3, 228–37 (*July*, 1954) In German.

The electrical resistance of tin films deposited on glass at 0°C was measured as a function of temperature and layer thickness. From increasing thicknesses from 100 mμ the resistivity decreased to a value 30% less than the bulk resistivity (at 300 mμ). The temperature coefficient of resistance was investigated and found to depend on the deposition temperature and the consequent concentration of crystal defects.

C. A. HOGARTH

537.311.32

4640. The electric conductivity of crystalline methylene blue. K. GUMIŃSKI AND W. ROMANOWSKI. *Bull. Acad. Polon. Sci. Cl.* 3, **2,** *No.* 10, 485–8 (1954).

The dark resistance of the dye is measured from 10° to 90°C and shows a similar behaviour for twenty samples. A single activation energy of $0\cdot92 \pm 0\cdot05$ eV is found.

G. F. J. GARLICK

537.311.32

4641. Electron bombardment conductivity in alkali halide crystals. I. C. YAMANAKA AND T. SUITA. Note in *J. Phys. Soc. Japan,* **10,** *No.* 3, 238–40 (*March*, 1955).

KCl crystals are bombarded with electrons of up to 5 kV with applied fields on the crystals up to 15 000 V/cm. To minimize space charge effects a steady electron beam was used with alternating applied field and then a pulsed beam used with a static field. Positive hole currents were very small and decayed rapidly. The lifetime of carrier electrons is estimated to be $0\cdot15\mu$sec.

G. F. J. GARLICK

537.311.32 : 548.736.3

4642. Densitometric and electrical investigation of boron in silicon. F. H. HORN. *Phys. Rev.*, **97,** *No.* 6, 1521–5 (*March* 15, 1955).

New analytical, X-ray diffraction, precision density and electrical resistivity studies of boron-doped silicon show that boron resides in the silicon lattice substitutionally.

A.

537.311.33

4643. Semiconducting materials. R. E. AITCHISON. *Austral. J. Sci.*, **17,** *No.* 2, 53–4 (*Oct.*, 1954).

Reviews the main features of the Gp IV elements which determine their usefulness in transistor physics and discusses how the III–V and II–VI compounds may replace Ge and Si in some applications.

C. A. HOGARTH

537.311.33

4644. Thermal ionization and capture of electrons trapped in semiconductors. H. GUMMEL AND M. LAX. *Phys. Rev.*, **97,** *No.* 6, 1469–70 (*March* 15, 1955).

The use of Coulombic wave-functions rather than plane waves for the free electron states is found to increase the calculated rate of capture of electrons by a factor of about 200 at liquid helium temperatures. Results calculated for shallow traps in Ge and Si are now found to be consistent with the upper limit set on the photoconductive lifetime by the experiment of Burstein, Overly and Davisson. The Born–Oppenheimer and Hartree approximations used in the calculations were found to yield identical results at low temperatures in these materials.

A.

537.311.33

4645. Space-charge-limited currents in solids. A. Rose. *Phys. Rev.*, **97**, *No.* 6, 1538–44 (*March* 15, 1955).

Currents, far in excess of ohmic currents, can be drawn through thin, relatively perfect insulating crystals. These currents are the direct analogue of space-charge-limited currents in a vacuum diode. In actual crystals, the space-charge-limited currents are less than their theoretical value for an ideal crystal by the ratio of free to trapped carriers. Space-charge-limited currents become, therefore, a simple tool for measuring the imperfections in crystals even in the range of one part in 10^{15}. The presence of traps not only reduces the magnitude of space-charge-limited currents, but also is likely to distort the shape of the current-voltage curve from an ideal square law to a much higher power dependence on voltage. The particular shape can be used to determine the energy distribution of traps. The presence of traps tends to uniformize the charge distribution between electrodes, to introduce a temperature dependence of the current, and to give rise to certain transient effects from which capture cross-sections of traps may be computed. Space-charge-limited currents offer another mechanism for electrical breakdown in insulators. A.

537.311.33

4646. Space-charge-limited currents in single crystals of cadmium sulfide. R. W. Smith and A. Rose. *Phys. Rev.*, **97**, *No.* 6, 1531–7 (*March* 15, 1955).

Currents as high as 20 amperes per cm^2 can be drawn through thin insulating crystals of CdS in the dark. A series of experiments demonstrate with a high degree of certainty that these are space-charge-limited currents—the solid-state analogue of space-charge-limited currents in a vacuum. This conclusion is contrary to a recently published interpretation of similar observations on CdS crystals by Böer and Kümmel. The use of pulsed voltages made possible the observation of currents close to those of a trap-free solid. The steady-stage currents are many orders of magnitude lower than these but still many orders of magnitude higher than would be expected from the low-field resistivity of the insulator. The presence of traps determines the form and magnitude of the steady-state current-voltage curves. Conversely, these curves become a sensitive tool for the measurement of trap densities. Trap densities computed independently from space-charge-limited currents and from photoconductive currents show reasonable agreement. A.

537.311.33

4647. The electrical conductivity of cadmium oxide at low temperatures. J. A. Bastin and R. W. Wright. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 312–15 (*April*, 1955).

Measurements of the variation of conductivity with temperature in the range 1°K–250°K together with similar measurements by Wright [Abstr. 5407 (1951)] in the range 100°K–700°K are compared with the theoretical expression for the conductivity in an ionic crystal derived by Howarth and Sondheimer [Abstr. 6781 (1953)]. The comparison gives the number of free electrons and the characteristic temperature for each specimen. The resistance at zero temperature is discussed in relation to impurity scattering and crystalline boundary resistances. A.

537.311.33

4648. The energy-dependence of the conductivity induced in layers and single crystals of CdS during bombardment by electrons. S. M. Rŷvkin, B. M. Konovalenko and Yu. S. Smetannikova. *Zh. tekh. Fiz.*, **24**, *No.* 6, 961–77 (1954) In Russian.

Electron energies of 2–30 keV were used. A plot of induced conductivity per unit energy flux against energy shows that the conductivity is almost constant in the range 10–30 keV, but falls off sharply at lower energies. The fall in the effect at 10 keV is connected only with the change in the penetrating power of the electrons, since the ionizing power of the electrons does not change significantly in the range of energies used. The results are compared with a theory which assumes an insensitive layer approximately 10^{-5} cm thick on the surface of the specimens. The drop in the photoconductive response on the short-wavelength side of the intrinsic absorption edge is also attributed to the failure of such light to penetrate this insensitive layer. J. M. RADCLIFFE

537.311.33

4649. Electrical properties of gallium antimonide. D. P. Detwiler. *Phys. Rev.*, **97**, *No.* 6, 1575–8 (*March* 15, 1955).

Data are presented on the conductivity and Hall coefficient of several samples of GaSb over the temperature from −196°C to 650°C. The lowest room-temperature conductivity obtained was 12 ohm^{-1}. cm^{-1}. All material produced from zone-purified components was *p*-type. *N*-type material was produced by doping with tellurium, as were *p–n* junctions. The intrinsic band gap is estimated from junction rectification data to be 0·78 eV at −196°C. The mobility of electrons was found by measurement on *n*-type material to be several times greater than the hole mobility. The mobilities of both holes and electrons are found to vary approximately as $T^{-\frac{3}{2}}$ in the lattice scattering range. A.

537.311.33 : 541.135.5

4650. Experiments on the interface between germanium and an electrolyte. W. H. Brattain and C. G. B. Garrett. *Bell Syst. tech. J.*, **34**, *No.* 1, 129–76 (*Jan.*, 1955).

Measurements have been made of the electrode potential of *p*- and *n*-type germanium in contact with aqueous solutions of KOH, KCl and HCl as a function of anodic and cathodic current and of incident light intensity. For anodic currents, the measured electrode potential can be separated into three parts: the reversible electrode potential corresponding to the anodic reaction, depending only on the solution; an overvoltage of the usual form; and a term $(kT/e) \ln (p_1/p)$, where p is the equilibrium hole concentration and p_1 is the concentration just inside the space-charge region of the germanium. The anodic current is determined by flow of holes to the surface, so that the current saturates for *n*-type germanium but not for *p*-type. The saturation current is determined by body and surface generation of holes and by creation of excess holes by light. There is a current gain of 1·4 to 1·8. In addition, there is a small "leakage" current not dependent on hole supply. Similar statements may be made for cathodic current, except that the

electrode potential and current are determined respectively by the concentration and supply of electrons instead of holes, the current gain is of the order of unity, and the leakage current is larger. Complicating time changes were observed for cathodic but not for anodic currents. The measurements may be understood in terms of simple thermodynamic considerations, based on the idea that the anodic reaction is with holes, the cathodic reaction with electrons, in the semiconductor; the behaviour for very small currents depends on a competition between the anodic and cathodic reactions, which may be treated by simple rate process considerations. A comparison is made with experiments on the germanium-gas interface by Brattain and Bardeen [Abstr. 1637 (1953)], to which similar considerations may apply. A.

537.311.33 : 538.632

4651. On the Hall effect of *p*-type germanium in the near intrinsic range. Y. Kanai and K. Furusyo. Note in *J. Phys. Soc. Japan*, **10**, *No.* 2, 165–6 (*Feb.*, 1955).

Measurements of R as a function of magnetic field H up to 7000 Oe for highly pure *p*-type Ge in the range 20–85°C so as to pass the transition from *p*-type to intrinsic. A marked variation of R with H is observed particularly in the transition region and is opposite in sense to the predictions of Madelung [Abstr. 4518 (1954)]. C. A. HOGARTH

537.311.33

4652. Sparked hydrogen treatment of germanium surfaces. N. Holonyak, Jr and H. Letaw, Jr. Letter in *J. appl. Phys.*, **26**, *No.* 3, 355 (*March*, 1955).

A spark discharge to Ge rods in low pressure hydrogen causes a much increased surface recombination velocity. Similar treatment to In/Ge *p–n* junctions causes an augmented reverse current (2 or 3 times) but reduces hole storage. C. A. HOGARTH

537.311.33

4653. Theory of the infrared absorption of carriers in germanium and silicon. A. H. Kahn. *Phys. Rev.*, **97**, *No.* 6, 1647–52 (*March* 15, 1955).

The Drude–Zener theory of optical absorption by free carriers is applied to the infrared absorption of *n*-type germanium and *p*-type silicon. Average effective masses so determined are: for electrons in germanium $\langle(m^*/m)\rangle_{Av}$ ranges from 0·11 to 0·22; for holes in silicon $\langle(m^*/m)\rangle_{Av}$ ranges from 0·19 to 0·55. The average effective mass values of electrons in germanium are in good agreement with those measured by cyclotron resonance. The infrared absorption bands of *p*-type germanium are explained on the basis of transitions of holes between three energy bands lying near the top of the valence band. This band structure is suggested by cyclotron resonance experiments. Application of the theory to *p*-type silicon leads to the prediction of an absorption peak near 25 μ and two lesser ones near 33 μ. A.

537.311.33 : 535.345

4654. Infrared absorption of germanium near the lattice edge. G. G. Macfarlane and V. Roberts. Letter in *Phys. Rev.*, **97**, *No.* 6, 1714–16 (*March* 15, 1955).

Accurate measurements down to 4·2°K on 60 ohm. cm material are reported. The results are well represented by a given two-term law which is to be expected on the basis of theoretical predictions involving optically forbidden transitions. The variation of energy gap E_G and intrinsic carrier concentration with temperature are estimated from the results and a theoretical value of K is given. The variation of E_G with T is quadratic at very low temperatures. C. A. HOGARTH

537.311.33

4655. Thermal acceptors in germanium. R. J. Hodgkinson. *Phil. Mag.*, **46**, 410–21 (*April*, 1955).

Results previously reported [Abstr. 6607 (1954)] are examined on the assumption that the thermal acceptors are copper atoms. A thermodynamic treatment of the solid solubility of copper in germanium is given in terms of the Principle of Lowest Free Energy, enabling a physical picture of the solubility to be given. This explains the approximately exponential dependence on inverse absolute temperature (below 800°C), which formerly led to the belief that thermal acceptors were lattice defects. An equation is derived which relates the concentrations of copper on the liquidus and solidus to the temperature. The experimental results are shown to obey this equation, which is equivalent to the one previously derived by Thurmond and Struthers using a different approach. A.

537.311.33

4656. Effects produced by the ionic bombardment of germanium. W. D. Cussins. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 4, 213–22 (*April*, 1955).

Specimens of pure single-crystal germanium and of polycrystalline germanium with varying amounts of impurity have been bombarded with positive ions of a number of elements having energies from 5 to 90 keV. The changes in some electrical properties of the specimen caused by this bombardment have been measured. In all cases it was found that maximum change was caused by a bombardment equivalent to about 6 μc. cm^{-2}. No changes were observed with ion energies less than about 20 keV. The results are consistent with the assumption that bombardment produces a *p*-type layer whether the original specimen was *p*-type or *n*-type. The thickness of this layer has been measured for various energies of the incident ions. A.

537.311.33

4657. Hall effect and magnetoresistance in lead, copper and magnesium. E. S. Borovik. *Zh. éksper. teor. Fiz.*, **27**, *No.* 3(9), 355–68 (1954) In Russian.

Reports results of extensive measurements of the Hall effect and magnetoresistance of polycrystalline samples of pure Pb, Cu and Mg in the temperature range 2°K–300°K. Magnetic fields up to 25 kilogauss were used. The mobilities and the densities of the carriers are determined by comparison of the results with the theory for an isotropic metal with two overlapping bands. Mobilities obtained in this way are compared with those deduced from size effects and the skin effect. There are 11 diagrams, 5 tables and 30 references to the literature. J. M. RADCLIFFE

537.311.33 : 538.567

4658. The resistance and photoconductivity of lead sulphide photocells at high frequencies. V. V. Balakov and V. A. Smeshkova. *Zh. tekh. Fiz.*, **24**, *No.* 6, 989–92 (1954) In Russian.

It is first shown that the use of aquadag electrodes

gives a spurious fall in resistance with increasing frequency. Cells with metallic electrodes ~10 mm apart showed a significant fall only on cooling. The effect of distributed capacity appeared already at 50–75 Mc/s when the electrode separation was reduced to 2·8 mm. The photoconductivity was found to be constant up to the highest frequency used, 180 Mc/s. These results agree with those of Humphrey *et al.* [Abstr. 4093 (1953)]. J. M. RADCLIFFE

537.311.33

4659. Mobility of electrons and holes in the polar crystal, PbS. R. L. PETRITZ AND W. W. SCANLON. *Phys. Rev.*, **97**, *No.* 6, 1620–6 (*March* 15, 1955).

From measurements of the Hall effect and resistivity on single crystals of PbS, the mobility of electrons and holes has been found over the temperature range 77–600°K. The crystals had donor or acceptor concentrations in the range 10^{16}–10^{19}/cm^3. These data are used to critically examine theoretical work on the mobility in polar crystals and to obtain estimates of the effective masses of electrons and holes. The perturbation theory of Fröhlich and Mott (F-M), and Howarth and Sondheimer (H-S) for the scattering of electrons by the polar (optical) modes of the lattice vibration is first considered. The expansion parameter of the perturbation theory is evaluated as 0·28 $(m_e^*/m_e)^{\frac{1}{2}}$ from published data on PbS; m_e is the free and m_e^* is the effective electron mass. The polaron theory of mobility of Low and Pines, which has been developed to replace the perturbation theory when the expansion parameter approaches or exceeds unity, is then discussed. m_e^*/m_e is the only unknown parameter in the two theories. The mobility data is first compared with the F-M, H-S theory from which $m_e^*/m_e = 0{\cdot}33$, $m_h^*/m_e = 0{\cdot}36$. These effective masses, when substituted in the Hall equation, provide for reasonable agreement with the Hall data. However, at high and low temperatures, discrepance exists between the theoretical and experimental mobility curves. Comparison of the mobility data with the polaron theory shows that the polaron theory is nearly identical with the F-M, H-S theory at low temperatures. The polaron theory has not been completed for the high temperature region. Since the data does not indicate the presence of impurity scattering, an analysis is made combining polar (F-M, H-S theory) and acoustical scattering, which yields $m_e^*/m_e = 0{\cdot}22$ and $m_h^*/m_e = 0{\cdot}10$. These effective masses give theoretical Hall curves in reasonably good agreement with the data. While the theoretical and experimental mobility curves now agree at low and intermediate temperatures, discrepancy still exists at high temperatures. Possible reasons for the discrepancy are discussed. It is concluded that the most likely source of error lies in perturbation theory expressions for the scattering cross-sections for electron energies greater than that corresponding to the frequency of the polar vibration. Comparison of the high temperature data with the polaron theory awaits further development of the theory and should provide a sensitive test of the general polaron theory, as well as being of interest in the theory of mobility in polar crystals. A.

537.311.33

4660. Theory of donor levels in silicon. W. KOHN AND J. M. LUTTINGER. Letter in *Phys. Rev.*, **97**, *No.* 6, 1721 (*March* 15, 1955).

The positions of low-lying excited levels are estimated using effective mass data and a band model deduced from cyclotron resonance experiments.

C. A. HOGARTH

537.311.33

4661. Excited donor levels in silicon. W. H. KLEINER. Letter in *Phys. Rev.*, **97**, *No.* 6, 1722–3 (*March* 15, 1955).

Excited levels of a monovalent donor impurity are calculated in the effective mass approximation using the known anisotropy of the effective mass. The results enable certain infrared absorption lines to be identified. C. A. HOGARTH

537.311.33

4662. Polarization in thorium oxide crystals. W. E. DANFORTH. Letter in *J. chem. Phys.*, **23**, *No.* 3, 591–2 (*March*, 1955).

The current flowing in single thoria crystals made *in vacuo* increases slowly to a constant value over many hours. It is concluded that electrons and positive ions are free to move, the shift of the latter depending on applied field strength. G. F. J. GARLICK

537.311.33

4663. Theory of the phenomena in a contact zone. G. M. AVAK'YANTS. *Zh. éksper. teor. Fiz.*, **27**, *No.* 3(9), 333–46 (1954) In Russian.

The problem of considering the temperature rise of the electrons (variations of their mean kinetic energy) in the electric field in calculations of the phenomena within a contact zone is investigated. One individual solution method of the problem is shown. It is applied to a contact metal–semiconductor (at constant current) for which the residual resistance is calculated, considering the two cases of strong and weak influence of the admixture levels in the contact zone. The results show that it is necessary to consider the temperature rise of the electrons even where the influence of the admixture levels is weak. The temperature rise of the electrons is revealed as the main effect of a strong electric field which, however, does not substantiate where equilibrium conditions exist, i.e. in the absence of a current; on the other hand, the tunnel effect is possible even in equilibrium states and may thus precede a temperature rise of the electrons, although this effect is particularly marked only in the case of strong fields. Impact ionization and dependence of the mobility and diffusion coefficient on the field strengths, thermocurrents in the contact zone and electron oscillations in this zone are also consequences of temperature rises of the electrons and are usually only observed in strong fields, e.g. electron oscillations between the boundaries of the zone cannot occur where the temperature rise is small, since for appreciable oscillations all the electrons must have a mean kinetic energy exceeding the value kT. Disregarding the effects associated with the finite width of the zone, the problem can be represented by a system of integro-differential equations first given by Davydov. However, the exact solution of this system is practically impossible. The simplification of this system leads to another system of non-linear partial differential equations which prove to be solvable when their

number has been supplemented from tabulated relations between the distribution functions involved. The two cases of the Schottky-layer and Davydov-layer (strong and weak influence of the admixture levels) are then treated separately. B. F. KRAUS

537.311.33

4664. On the blocking layer of selenium rectifier. I. J. YAMAGUCHI, T. KANAZAWA, T. MATOZAKI AND K. HIRAI. Note in *J. Phys. Soc. Japan*, **10**, *No.* 3, 233–4 (*March*, 1955).

The capacity of Se rectifiers with and without an organic insulating film between the Cd and Se layers is measured as a function of applied d.c. reverse voltage. For thin resin films (up to 500 Å) there are minute holes allowing the migration and combination of Cd and Se. In all cases CdSe is expected to be present and to play a major rôle in the rectification. C. A. HOGARTH

537.311.33

4665. On the blocking layer of selenium rectifier. II. J. YAMAGUCHI. Note in *J. Phys. Soc. Japan*, **10**, *No.* 3, 234–6 (*March*, 1955).

A Se rectifier consisting of layers Cd, CdSe, Se, Fe was ground obliquely at one side thereby exposing layers one after the other. Thermoelectric and rectification probing with a tungsten whisker provided evidence that the seat of rectification was at the CdSe/Se interface. C. A. HOGARTH

537.311.33

4666. A method of making silicon junction diodes. J. W. GRANVILLE. Letter in *Brit. J. appl. Phys.*, **6**, *No.* 3, 109 (*March*, 1955).

A new technique for producing *p–n* junctions is described. W. BARDSLEY

537.311.33

4667. Properties of ohmic contacts to cadmium sulphide single crystals. R. W. SMITH. *Phys. Rev.*, **97**, *No.* 6, 1525–30 (*March* 15, 1955).

The usual materials and techniques for making electrical contact to CdS single crystals are not satisfactory. The *V–I* characteristics are erratic and non-linear, the photocurrent noise is excessive and there is a spurious photovoltaic effect, all associated with poor, high-resistance contacts. It has been found that In and Ga make ohmic contact to the crystals. With ohmic contacts the disturbing effects of the barriers are removed and measurements of the electrical characteristics of the crystals can be made with confidence. In addition, maximum performance can be obtained from the crystals. From the measurements it is shown that there can be large volume photosensitivity in CdS, and that the surface and volume (dark) conductivity of a crystal can differ greatly. Typical *V–I* characteristics are presented demonstrating (1) The improved performance obtained from a photosensitive CdS crystal with In contacts compared with that obtained with the An contacts; (2) broad-area CdS crystal rectifiers. One was made from highly conducting crystals from which a forward current density $\sim$1 amp/cm^2 was obtained at 1·5 volts with a front to back current ratio of 10^6. The other, a rectifier-photoconductive cell, was made from an insulating photosensitive crystal. In the forward direction the gain was $>10^4$ at 6 volts (corresponding to $\sim$10 amp/lumen). (3) Space-charge-limited current in an insulator. The current is time dependent and increases more rapidly with voltage than the square-law theoretically predicted for a perfect insulator. The effect of crystal imperfections in determining the *V–I* characteristics is indicated. A.

537.311.33

4668. The effect of discontinuous space charge on rectifier characteristics. G. G. WILES. *Phil. Mag.*, **46**, 363–75 (*April*, 1955).

Theoretical. An expression is derived for the local current density in the blocking direction near any impurity centre that happens to be situated at an optimum distance from the metal. Numerical examples are given. The effects of these large local currents on the average current through the interface is evaluated in the case of a uniform distribution of impurity centres. When the semiconductor has a dielectric constant of 10 the error at room temperature caused by assuming the usual continuous distribution of space charge is found to be very small with 10^{16} impurity centres per cm^3, but becomes appreciable at 10^{18}. The case of a random distribution is treated by a more approximate method but this is considered to be a more satisfactory method than that used by Schottky. The results are much the same as for the case of a uniform distribution. A.

537.312.5

4669. Properties of KCl crystals containing metallic thallium centres. Photoelectric effect. J. ROHLEDER. *Bull. Acad. Polon. Sci. Cl.* 3, **2**, *No.* 9, 443–6 (1954).

Crystals with 4×10^{-3} molec. % Tl show photoconductivity proportional to applied field and light intensity. Spectral sensitivity depends on Tl content and excess K but peaks are observed at 5 500 and 8 200 Å. G. F. J. GARLICK

537.312.5

4670. Determination of the optical activation energy of germanium by the method of photoelectric lines. J. TAUC. *Czech. J. Phys.*, **4**, *No.* 3, 311–15 (*Sept.*, 1954).

From the dependence of the photovoltage of the *p–n* junction on the temperature of black body radiation, with which the junction is illuminated, the optical activation energy of germanium $E_0 = 0{\cdot}62 \pm 0{\cdot}02$ eV at 300°K is determined. On the basis of this measurement, and an analysis of the conductivity and optical measurements given in the literature, reasons are presented which render probable the conclusion that the optical activation energy of germanium is equal to the width of the band of forbidden energy values, of magnitude $E_G = 0{\cdot}75 - 4\times10^{-4}T$ eV. A.

537.312.5

4671. Energy distributions of photoelectrons from Au and Ge in the far ultraviolet. W. C. WALKER AND G. L. WEISSLER. Letter in *Phys. Rev.*, **97**, *No.* 4, 1178–9 (*Feb.* 15, 1955).

Distributions are investigated by the retarding potential method for photon energies from 10–18 eV, well above thresholds. For such energies relatively few electrons are emitted with energies near the maximum value, in contrast to the behaviour for lower photon energies. G. F. J. GARLICK

537.312.5

4672. Photoelectric effect of selenium photopiles at low temperatures. G. BLET. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 9, 962–3 (*Feb.* 28, 1955) In French.

The photoelectric sensitivity for wavelengths ~0·5μ was measured at temperatures between 88°K and 295°K. It was found to increase with temperature at a faster than linear rate of proportionality. Spectral sensitivity measurements in the range 0·4μ to 1μ for an incandescent lamp at a colour temperature of 2780°K, as measured with the photopile, gave a bell-shaped curve which diminished in amplitude if the temperature of the photopile was reduced; the position of the maximum shifted towards the lower-wavelength end of the spectrum. C. G. MORGAN

537.312.5 : 534.39 : 535.371 : 534.321.9

The effect of ultrasound on the conductivity and fluorescence of zinc and cadmium sulphide crystals. *See Abstr.* 4467

537.312.5 : 535.33.07

4673. Photoconductive detectors for infra-red spectroscopy. A. S. YOUNG. *J. sci. Instrum.*, **32,** *No.* 4, 142–3 (*April*, 1955).

A method of constructing lead telluride infrared photoconductive cells, sensitive at liquid oxygen temperature, is described. Details are given of the performance of the cells when used as detectors in infrared spectrometers. A.

537.312.5 : 537.311.33

4674. A sensitive method of investigating the internal photoeffect in powdered semiconductors by dielectric loss measurements. M. BORISOV. *Izv. Bulg. Akad. Nauk.*, **3,** 91–8 (1952; publ. 1954). In Bulgarian. Summaries (200 words) in Russian and German.

The method presented determines the variations of the dielectric losses under illumination which produce variations of the grid current of an h.f. oscillator, the oscillation circuit of which contains a capacitor the dielectric of which is the substance investigated. The actual measuring method is a compensation method by which variations of the order of 10^{-6} of the initial grid current may be observed. The variations of the grid current depend linearly on the variations of the equivalent h.f. admittance of the oscillation circuit. The author presents the curves of the variations of the dielectric losses under illumination and darkening of Zn 25% CdS, Cu, and the corresponding curves plotted for infrared irradiation, and also the recorded curves of the internal photoeffect of ZnS.Zn and ZnO.

B. F. KRAUS

537.312.5 : 537.311.33

4675. The photoeffect from surface levels. G. E. PICUS. *Zh. éksper. teor. Fiz.*, **27,** *No.* 3(9), 369–81 (1954) In Russian.

Theoretical. Treats the external photoeffect due to electrons in the surface layers of semiconductors and dielectrics. The energy distribution of the emitted electrons and the frequency dependence of the quantum efficiency are discussed. It is concluded that in the case of full or half-filled surface zones, such a photocurrent forms an essential part of the total photocurrent from a semiconductor.

J. M. RADCLIFFE

537.312.5 : 538.632

4676. Photodiffusion current Hall effect: transient behavior. L. H. HALL. *Phys. Rev.*, **97,** *No.* 6, 1471–4 (*March* 15, 1955).

Illumination at the surface of a semiconductor sample generates a photodiffusion current, and a magnetic field applied transversely to the flow develops a Hall potential. Observation of the transient behaviour shows a voltage peak preceding the steady state value. A theoretical account of this behaviour is given under simplifying assumptions. A.

537.312.5 : 621.383.27

4677. Theoretical study of the working of the last stage of a photomultiplier. P. LEUBA. Letter in *J. Phys. Radium*, **16,** *No.* 2, 161–2 (*Feb.*, 1955) In French.

Indicates how comparison of an expression derived for the change in voltage on the collecting electrode with experimental results can give information about the duration and time variation of the radiation exciting the photomultiplier. J. DUTTON

537.312.62

4678. On the theorem of reciprocity in the stationary superconducting state. M. MARZIANI. *R.C. Accad. Naz. Lincei*, **17,** *No.* 5, 229–34 (*Nov.*, 1954) In Italian.

It is proved that the relation $[\vec{M}_1 \times \vec{H}_2(O_1)] = [\vec{M}_2 \times H_1(O_1)]$ holds in the presence of a singly connected superconductor where $\vec{H}_1$ and $\vec{H}_2$ are the stationary magnetic fields produced by the magnetic dipoles $\vec{M}_1$ and $\vec{M}_2$ situated at the points O_1 and O_2 outside the superconductor. The theorem is applied to the screening effect of a hollow superconducting sphere. H. LONDON

537.312.62

4679. Simultaneous oscillographic recording of resistance and magnetic flux for indium single crystals in the transition region to superconductivity at high current loads. W. MEISSNER AND R. DOLL. *Z. Phys.*, **140,** *No.* 3, 340–58 (1955) In German.

Detailed account and discussion of Abstr. 2767 (1955). H. LONDON

537.312.62

4680. Change of the shear modulus of zinc at the transition from the normal to the superconducting state. P. GRASSMANN AND J. L. OLSEN. *Helv. phys. Acta*, **28,** *No.* 1, 24–32 (1955) In German.

Measurement of shear modulus, using a very sensitive static method, gives the result, for polycrystalline Zn, $\Delta G/G = 3{\cdot}5 \times 10^{-6}[1 - (T/T_c)^4]$ over the range $1{\cdot}7°K < T < 3{\cdot}73°K$. The room temperature resistivity suggests there may be strong preferred orientation of the c axis. This result differs from previous work by a factor of ten. W. M. LOMER

537.312.62

4681. Paramagnetic effect in superconductors. I. Theoretical aspects. H. MEISSNER. *Phys. Rev.*, **97,** *No.* 6, 1627–33 (*March* 15, 1955).

A theory for the paramagnetic effect is developed under the assumption that the ratio of the effective length to the effective diameter l/a of the superconducting particles in the transition region is constant.

While experiment shows that the relative apparent permeability K_m is a function of $\gamma = \phi_0(1 - I_g/I)$, where $\phi_0 = H_{\phi 0}/H_{z0}$, $H_{\phi 0}$ is the circular and H_{z0} the longitudinal component of the field at the surface, I_g is a limiting current, and I the total current through the sample, this theory gives the permeability as a function of ϕ_0 only. Good agreement with the experimental range of K_m, however, is obtained when the theoretical value of ϕ_0 is replaced by γ. The experiments of the author *et al.* on solid and hollow mercury cylinders and recent experiments of Thompson and Squire on a solid tin cylinder are discussed. A reason why the theoretical value of ϕ_0 has to be replaced by γ cannot be given at this time, although it is indicated where the present theory has to be amended. A.

537.312.62

4682. Superconducting transitions in tin whiskers. O. S. Lutes and E. Maxwell. Letter in *Phys. Rev.*, **97**, *No.* 6, 1718–20 (*March* 15, 1955).

The restoration of resistance by a transverse field in very thin short tin wires ("whiskers," $1{\cdot}2 \times 10^{-4}$ cm dia. 50×10^{-4} cm long) is much sharper than for the thicker wires studied by Andrew [Abstr. 2473 (1954)]. It is suggested that for such thin wires the intermediate state may not occur at all. D. SHOENBERG

537.312.62

4683. Superconductivity of uranium. J. E. Kilpatrick, E. F. Hammel and D. Mapother. *Phys. Rev.*, **97**, *No.* 6, 1634–5 (*March* 15, 1955).

Superconductivity has been found in three samples of uranium. The transition is broad (0·2 to 0·3°K wide), and is centred at 0·77°K for two samples and at 0·80°K for the third. A.

537.312.62 : 536.21

4684. Thermal conduction in the intermediate state of superconductors. S. J. Laredo and A. B. Pippard. *Proc. Cambridge Phil. Soc.*, **51**, *Pt* 2, 368–76 (*April*, 1955).

The maximum in thermal resistivity exhibited by superconductors in the intermediate state is found to be particularly marked in tin at 0·5°K, at which temperature heat transport in the pure superconducting state is almost entirely by phonons. A simple theory of the effect is developed, based on the idea that phonon free paths are considerably shorter in the intermediate than in the superconducting state, owing to the high scattering caused by normal regions. Theory and experiment are in satisfactory agreement. A.

537.312.62 : 536.48 : 532.6

Transfer of mass and charge by surface waves. *See Abstr.* 4409

537.312.8

4685. Anomalous longitudinal magnetoresistance of metal single crystals. M. C. Steele. Letter in *Phys. Rev.*, **97**, *No.* 6, 1720 (*March* 15, 1955).

Curves of the increase of resistance of an Sb crystal plate in longitudinal magnetic fields up to 60 kG (trigonal axis perpendicular to length of plate) show anomalous features at low temperatures. Below 78°K the curves show a maximum (of about 1·8 times the zero field resistance at 1·5°K for about 8 kG) and at 4·2°K and 1·5°K the resistance decreases below the zero field value beyond 30 kG and then approaches a constant value, less than half the zero field value. D. SHOENBERG

537.32

4686. Thermoelectric power of germanium at low temperatures. E. Mooser and S. B. Woods. Letter in *Phys. Rev.*, **97**, *No.* 6, 1721–2 (*March* 15, 1955).

Measurements on two samples at low temperatures provide evidence for an additional term Q_p in the thermoelectric power, arising from a "phonon-drag" effect, predicted by Gurevich (1945, 1946). C. A. HOGARTH

537.324

4687. Thermal e.m.f. of a couple (thin film of Cu in contact with solid Ag). Variation with layer thickness. H. Benel. *Rev. Fac. Sci. Univ. Istanbul C*, **19**, *No.* 2, 162–8 (*April*, 1954) In French.

Measurements made on thin films deposited and measured in the same vacuum system, thereby preventing the oxidation previously caused by removing from the system for measurement. The thermal e.m.f. decreases as the layer thickness increases and only reaches its limiting value for thicker crystalline layers. C. A. HOGARTH

ELECTRIC DISCHARGES 537.52

537.521.7

4688. Investigation of the speed of development of the leader of a long spark. I. S. Stekol'nikov and M. A. Bagirov. *Zh. éksper. teor. Fiz.*, **27**, *No.* 2(8), 189–94 (1954) In Russian.

The relation between speed of propagation of the leader of a long spark (50–400 cm), magnitude of the damping resistance in the discharge circuit (R_d = 0·74–100 kilo-ohm), electrode distance and overvoltage factor in the discharge gap (k = 1–2) was investigated. The average propagation speed of the leader was found to be independent of the electrode distance if the length of the discharge gap was near the minimum sparking distance in impulse conditions. The magnitude of the damping resistance has the greatest influence on the propagation speed of the leader, viz. for a reduction of R_d from 1 500 to 0·74 kilo-ohm, the average leader speed increases from $1{\cdot}5 \times 10^6$ to $1{\cdot}54 \times 10^7$ cm/sec. In weakly damped discharges (R_d = 1·65 kilo-ohm and less) the average speed of the leader in the "section of free development" approaches the speed of the leader in a lightning discharge. However, the leader speed does not remain constant over the discharge space and increases when the leader approaches the earthed plane. The character of the speed variation also depends on the damping resistance; if this is 5 kilo-ohm and less, the speed increases rapidly from the first ¼ of the length of the discharge space. The speed maximum occurs immediately before the formation of the main channel and becomes $1{\cdot}6$–$1{\cdot}65 \times 10^8$ cm/sec for R_d = 0·74 kilo-ohm. With increasing overvoltage

factor the leader speed increases approximately linearly when the gap lengths are 100–300 cm.

B. F. KRAUS

537.523.3 : 537.563

4689. Permanent dissociation of sulphur hexafluoride in corona discharges. R. THORBURN. Letter in *Nature* [*London*] **175**, 423–4 (*March* 5, 1955).

Describes mass-spectrometer studies of dissociation in SF_6 due to corona discharges. The results, which are of a preliminary nature, show that formation of free fluorine is a predominating reaction.

J. D. CRAGGS

537.523.4

4690. Changes of state on the electrodes in condensed discharges. V. HERMOCH, B. ZÍTKA AND K. ŠOBRA. *Czech. J. Phys.*, **4**, *No.* 4, 486–95 (*Nov.*, 1954) In Russian. Summary (1½ pp.) in English.

An experimental study of the electrode spots in condensed spark discharges. On the assumption that the discharge current flows into the luminous area of the spots, local current densities $\sim 10^5$ A/cm^2 occur. Various techniques are described with which, for example, the spot movements during the discharge may be followed.

J. D. CRAGGS

537.523.4

4691. Studies of the mechanism of electrically "exploded" wires. W. M. CONN. Note in *Naturwissenschaften*, **42**, *No.* 3, 65–6 (1955).

Suggests a mechanism for the exploded wire "discharge" involving the formation of a cylindrical metal vapour shell, and the reflection of the initial wire explosion shock wave inside the vapour shell.

J. D. CRAGGS

537.523.4

4692. Electron avalanches and their development in self-maintained discharges. H. RAETHER. *Z. angew. Phys.*, **7**, *No.* 1, 50–6 (1955) In German.

A review of various methods of studying electron avalanches, with a discussion dealing particularly with avalanche-streamer transitions in over-volted uniform-field spark gaps. Avalanches may be studied with Wilson chambers, or with circuit techniques (special reference to proportional counter pulses is made here) or with photomultiplier tubes. Formative time data are discussed. It is suggested that streamers form when αd (Townsend's first ionization coefficient × gap length) exceeds about 18 in the usual units. For 1 cm uniform field gap at 1 atm in air an overvoltage of about 7% is needed and for roughly a 10 cm gap, streamer breakdown should occur at zero overvoltage.

J. D. CRAGGS

537.525 : 538.639

4693. Particle transport, electric currents, and pressure balance in a magnetically immobilized plasma. L. TONKS. *Phys. Rev.*, **97**, *No.* 6, 1443–5 (*March* 15, 1955).

An analysis of a plasma immobilized by a magnetic field shows that each kind of charged particle has a general drift perpendicular to the gradient of the field, but that there is no corresponding electric current density. There is an exact cancellation arising from the gradient of the Larmor radius. The current density which is present arises exclusively from the particle density gradient and is not associated with any drift of matter.

A.

537.525.5

4694. Ion and atom cross-sections in plasmas of different gases. H. MAECKER, T. PETERS AND H. SCHENK. *Z. Phys.*, **140**, *No.* 2, 119–38 (1955) In German.

The dependence between the temperature and conductivity in an arc discharge was used to ascertain the effective cross-section of the ions and atoms of H, C, N, O and Fe. Good agreement is obtained between the experimental results and values calculated by Spitzer [Abstr. 1059 (1951)]. Full details of the apparatus and experimental method are given.

C. G. MORGAN

537.525.5

4695. Influence of external radiation on an A–Hg discharge tube. T. ASADA, T. NAKAYA AND T. MAMURO. Note in *J. Phys. Soc. Japan*, **10**, *No.* 3, 241–2 (*March*, 1955).

Describes the effect of irradiating a hot cathode discharge in 4 mm Hg argon and mercury vapour; the partial pressure of the latter was controlled by alteration of the wall temperature of the tube. Visible light or u.v. was used for the irradiation, the effect of which on starting potentials was studied.

J. D. CRAGGS

537.525.6

4696. The oscillatory multiplication of secondary electrons. K. KREBS AND H. MEERBACH. *Ann. Phys.* [*Leipzig*] **15**, *No.* 3–4, 189–206 (1955) In German.

A continuation of previous work [Abstr. 1864 (1955)] on the multiplication of secondary electrons at electrode walls in high-frequency (~100 Mc/s), low-pressure ($\sim 10^{-6}$ mm Hg) discharges. An analysis of the conditions necessary for the existence of the multiplication process relating frequency, amplitude and electrode separation is given. The analysis is compared with experimental results obtained with Fe, Cu, Ag and Al, and also with results of other authors.

C. G. MORGAN

537.525.6 : 538.561

4697. High-frequency plasma-electron oscillations. K. G. EMELEUS AND R. A. BAILEY. *Brit. J. appl. Phys.*, **6**, *No.* 4, 127–8 (*April*, 1955).

Methods are considered for increasing the concentration of plasma electrons and the plasma electron frequency in low pressure gaseous discharges traversed by electron beams. Two discharges are described which generate oscillations with a frequency of approximately 10^4 Mc/s.

A.

537.525.72

4698. Production of Joshi effect in mercury vapour: time-variation of the h.f. and l.f. components of the conductivity under electrical discharge. B. B. PRASAD, M. S. RAJU AND H. S. NAGARAJAIAH. *J. sci. Res. Banaras Hindu Univ.*, **5**(1) 49–57 (1954–55; publ. *Dec.*, 1954).

Variation of the h.f. component of the conductivity i under discharge, which is the chief seat of Δi, is studied during the time-development of Δi in a fresh ozonizer. It is found that with ageing under discharge the h.f. part decreases, first rapidly and later slowly,

to reach a stationary value when Δi sets in. An irregular variation with time of ageing is, however, seen in case of the l.f. component; this also, after about 150 minutes of continuous exposure to discharge, attains a stationary value and then Δi occurs. In l.f. current a positive Joshi effect is observed; at low potentials $-\Delta i$ is predominant. A.

537.525.72

4699. Occurrence of negative and positive Joshi effects in electrostatic and electromagnetic regions of a selfmaintained a.c. discharge. II. Influence of external magnetic field. N. SUBRAHMANYAM. *J. sci. Res. Banaras Hindu Univ.*, **5**(1) 124–38 (1954–55; publ. *Dec.*, 1954).

For previous part, see Abstr. 10215 (1954). Variation with external magnetic field (H_e) of the negative and positive Joshi effects ($\pm\Delta i$) in iodine vapour excited by low (50 c/s) and radio (3·20 Mc/s) frequency potential (V), was investigated. In the electrostatic region of the discharge at V near the threshold potential (V_m), $H_e > 80$ and < 400 gauss decreased the conductively i and the associated pulses. At $V \gg V_m$ where the discharge was controlled chiefly by the electromagnetic field (H_i) produced internally by passage of ions, i was always augmented by H_e. Calculations showed that $H_i > 4500$ gauss was sufficient to maintain the discharge without the assistance of the electrostatic field. In agreement with earlier findings, $-\Delta i$ occurred in the electrostatic and $+\Delta i$ in the electromagnetic region. H_e inhibited $-\Delta i$ and enhanced the potential range of occurrence of $+\Delta i$. A.

537.525.8

4700. The decrease in operating voltage of a normal glow discharge due to cathode irradiation. W. KLUGE AND A. SCHULZ. Note in *Naturwissenschaften*, **42**, *No.* 2, 40 (1955) In German.

Shows how the "burning" voltage of an argon glow (~0·1 mm Hg pressure) with a Ag–KH–K cathode varies with the initial cathode current (usual symbol i_0). Varying the i_0 current density from about 0·005 to about 0·065 μA/cm^2 altered the discharge voltage (about 120 V) by some 10 V. J. D. CRAGGS

537.525.8

4701. A note on the constant longitudinal field in the positive column of a glow discharge. J. WILHELM. *Ann. Phys.* [*Leipzig*] **15**, *No.* 3–4, 148–54 (1955) In German.

Theoretical paper showing that on the assumption of the quasi-neutrality of the column, the necessary condition for the same radial current density to flow out through any section is a constant longitudinal field. J. DUTTON

537.525.8

4702. Joshi effect in relation to intermittent pulses. M. B. DESHIMUKH. Letter in *J. chem. Phys.*, **23**, *No.* 3, 593 (*March*, 1955).

Briefly describes certain intermittent pulse effects obtained with a hydrogen (69 mm Hg pressure) discharge tube with external electrodes. A 50 c/s applied voltage was used. The effect of irradiation with light was investigated. J. D. CRAGGS

537.525.8

4703. Inversion potential of the Joshi effect and light intensity. S. R. MOHANTY AND P. SRINIVASA RAO. Note in *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 3, 177–8 (*March*, 1955).

Describes further experiments on the effect of external irradiation of a Siemens ozonizer tube with reference to suggested mechanisms involving surface layers. J. D. CRAGGS

537.525.8

4704. Potential dependence of the Joshi effect inversion with light intensity. S. R. MOHANTY AND P. SRINIVASA RAO. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 4, 328 (*April*, 1955).

Describes further experiments on the Joshi effect, i.e. the change of discharge current in ozonizer tube discharges with external irradiation. The present experiments were made with naphthalene vapour. J. D. CRAGGS

537.527.5

4705. Plasma streams with supersonic velocity. T. PETERS. Note in *Naturwissenschaften*, **41**, *No.* 24, 571–2 (1954) In German.

Describes expts. on the properties of a luminous plasma stream issuing through a suitable nozzle from a high-pressure arc. From a discharge running at 12 500°K, a jet velocity of Mach 1·64 was obtained. The effect of introducing copper vapour into such a discharge is also briefly described. J. D. CRAGGS

537.529

4706. Breakdown of solid dielectrics in divergent fields. J. H. MASON. *Rep. Brit. Elect. Res. Assoc.*, *Rep. L/T*310, 24 (1954).

Breakdown channels are shown to propagate from needlepoint electrodes embedded in polyethylene and polyisobutylene when the maximum effective stress at the end of the point reaches the intrinsic electric strength of the material at the test temperature. The average breakdown stress shows no significant variation with the radius of curvature of the point (for radii of 1 to 20 μ), but (at room temperature) about 25% greater stress is required with a negative than with a positive point. These results are explained by the effect of enhanced conductivity and consequent space charge accumulation increasing the effective point radius to some 25 μ for positive and about 45 μ for negative points. The decrease of the average stress required for breakdown with increasing electrode separation is explained, and the same concept is used to predict the variation of the industrial electric strength of materials with specimen thickness. Factors affecting the industrial electric strength of materials are discussed and illustrated by tests on polyethylene, polystyrene and cellulose acetate, using B.S.I. electrodes in air and in clean and contaminated transformer oil. A.

X-RAYS 537.531

537.531 : 535.33

4707. On the identification of X-ray satellites. D. J. CANDLIN. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 322–8 (*April*, 1955).

The wave-numbers of $K\alpha$ satellites from $Z = 19$ to

$Z = 42$ are calculated with analytical wave-functions, and the spectroscopic terms from which the observed lines are derived are identified. A.

537.531 : 535.338

4708. X-rays excited by protons on Zn, Cu, Ni, Co, Fe. J. URBANEC AND Č. ŠIMÁNĚ. *Czech. J. Phys.*, **5**, *No.* 1, 40–8 (*Feb.*, 1955) In Russian.

Measurements of the dependency of the intensity of the K_α lines of X-ray radiation excited by protons on the energy of the protons was carried out on five adjoining elements. The measurements were carried out for an energy of the protons between 400 and 700 keV. The X-rays were analysed by a NaCl crystal in a Bragg spectrometer which was constructed for work in a space having a strong background of γ-rays produced in the accelerating tube by parasitic nuclear reactions. The detection of the reflected X-rays was carried out by a bell-type G.M. counter in a lead shield. The current of protons from the accelerator tube was focused on the target to a diameter of 2 to 3 mm. The protons were separated from the molecular ions by a magnetic analyser the magnetic field of which was automatically adjusted in such a manner that protons of all energies were always focused on the same place of the target. The ion current was integrated by an electronic integrator working linearly in the range 0–60 μA. The dependencies of the intensities of the K_α lines obtained differed somewhat from the dependencies foretold by Henneberg. The deviations are of the order of errors caused by statistical fluctuations on the one hand and probable small changes of the focus due to changes in the energy of the protons on the other. The experiment proved that the intensity of the K_α line decreased with increasing atomic number. An estimate of the ratio of the intensities could not be carried out due to the unknown primary and secondary extinction of the NaCl crystal used. Absorption measurements in the direct beam were therefore carried out and the dependence according to the theory of Henneberg was thereby proved. A.

537.531 : 535.338

4709. Isotope shift in the X-ray spectra of heavy elements. M. S. WERTHEIM AND G. IGO. *Phys. Rev.*, **98**, *No.* 1, 1–5 (*April* 1, 1955).

Isotope shifts in the X-ray levels due to the nuclear volume effect have been calculated for three different nuclear potentials by using first-order perturbation theory with the relativistic wave-functions in a Coulomb field. In order to correct for the error made in using first-order perturbation theory, the exact relativistic wave-function was obtained for one of the potentials. The screening effects of the atomic electrons are taken into account by comparing the value of the wave-function at the nuclear radius in a Fermi–Thomas field with that in a Coulomb field. An upper limit is obtained on contributions to the isotope shift due to the change in screening of the other atomic electrons when a K or L shell electron is removed or replaced. The results for isotope shift in Mo and U are one-half and one-twentieth respectively of the experimental resolution of Rogosa and Schwarz. A.

537.531 : 535.343

4710. Non-diagram lines in the K-spectrum of neon. J. BAČKOVSKÝ AND J. DRAHOKOUPIL. Letter in *Czech. J. Phys.*, **4**, *No.* 4, 507 (*Nov.*, 1954) In German.

The spectrum of neon corresponds (in accordance with Moseley's law) with the spectra of solid elements, and it is concluded from this that the non-diagram lines of solid elements are not affected appreciably by binding between atoms. A. R. STOKES

537.531 : 535.343 : 539.153

4711. L absorption spectra and energy levels of neodymium (60) and samarium (62). P. CALLON. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 6, 615–17 (*Feb.* 7, 1955) In French.

The electronic energy levels deduced from measurements of the absorption spectra of the oxides are tabulated. J. HUGHES

537.531 : 535.343 : 539.152.1

4712. A new determination of the K absorption frequencies of caesium (55) and of barium (56). P. CALLON. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 8, 854–5 (*Feb.* 21, 1955) In French.

These were measured with a mica curved crystal spectrometer, and the results and the electronic energy levels deduced from them are tabulated. J. HUGHES

CATHODE RAYS . POSITIVE RAYS 537.533/.534

537.533 : 621.384.61

4713. Strong focusing for particle accelerators. W. DÄLLENBACH. *Z. Naturforsch.*, **9a**, *No.* 12, 1005–12 (*Dec.*, 1954) In German.

Discusses the stability, periodicity and amplitude of betatron oscillations in terms of the coefficients relating radial input and output parameters for a single section. The deviations from the equilibrium orbit resulting from errors in the positioning of the magnets are calculated. For an assumed law of the distribution of errors, the r.m.s. value of the deviations can be expressed in terms of the r.m.s. values of the errors. An expression relating the variations of the mean orbit of the particles, executing synchrotron oscillations, to the range of their momentum values is derived, and shown to be in essential agreement with that obtained by E. D. Courant, M. S. Livingston and H. S. Snyder [Abstr. 907 (1953)]. E. A. ASH

537.533 : 621.384.612

4714. An electron injector for a 70-MeV synchrotron. A. J. BUREAU, H. A. AUSTRHEIM AND D. J. ZAFFARANO. Letter in *Rev. sci. Instrum.*, **25**, *No.* 11, 1129–30 (*Nov.*, 1954).

A brief description of the design of a three-electrode electron-gun. J. J. WILKINS

537.533 : 621.384.62

4715. The Stanford Mark II linear accelerator. R. F. POST AND N. S. SHIREN. *Rev. sci. Instrum.*, **26**, *No.* 2, 205–9 (*Feb.*, 1955).

Primarily intended as an intermediate stage before the eventual construction of a 1 BeV machine, it was designed to be a prototype of one of the many sections of the larger accelerator. Electron energies up to

nearly 40 MeV have been obtained, and peak beam currents of about 10 mA in 1 μsec pulses. The theoretical design and experimental testing procedures developed in constructing the loaded waveguide are outlined. A brief description of the auxiliary equipment, including a multi-megawatt klystron amplifier, is given. Operating characteristics of the accelerator are summarized. The machine has been in use since 1950 for experimentation in electron physics. A.

537.533 : 621.384.62

4716. An electron accelerator and high resolution analyzer. A. W. BLACKSTOCK, R. D. BIRKHOFF AND M. SLATER. *Rev. sci. Instrum.*, **26**, *No.* 3, 274–5 (*March*, 1955).

The principle of energy measurement by stopping potential has been extended to high-energy electrons, using conventional accelerating tubes. Defocusing effects which occur during deceleration are minimized by employing a low-energy cylindrical electrostatic analyser to measure the energy remaining in the beam after deceleration has been almost complete. The width of the line profile obtained by this technique appears to be largely independent of the primary energy of the electrons, the per cent resolution thus improving as the primary energy is increased. Resolution up to 20 parts per million at 100 keV is obtainable by this method. A.

537.533 : 621.385.1.029.6

4717. Flicker effect at ultra-high-frequencies. M. MUSSON-GENON. *Vide*, **9**, 203–5 (*July–Sept.*, 1954) In French.

A mechanism is proposed which is regarded as a working hypothesis. The effect (small saw-teeth observed on an output *v.* reflector voltage oscillogram) is considered to be associated with multiple passage of electrons and particularly with the presence of electrons close to the axial region of the beam. This last is supported by the fact that when the cathode has a central hole the effect cannot be detected. Electrons coming back through the resonator bombard the cathode and produce perturbations in emission.

S. C. DUNN

537.533.1

4718. Velocity spectrography of electron dynamics in a traveling field. O. T. PURL AND H. M. VONFOERSTER. Letter in *J. appl. Phys.*, **26**, *No.* 3, 351–3 (*March*, 1955).

The a.c. component of the velocity of an electron beam, modulated by a length of helix, is determined by means of an electrostatic velocity analyser. The variation of the a.c. velocity with time can be displayed by transverse deflection of the beam at the modulating frequency. Spectrograms corresponding to the case of a low current beam in exact synchronism with the travelling field are shown, and are in good agreement with theory. Results are also presented showing the decrease of the magnitude of the a.c. velocities as the beam velocity departs from the synchronous value.

E. A. ASH

537.533.2

4719. The theory of internal field emission. F. SAUTER AND J. WEISSE. *Z. Phys.*, **140**, *No.* 2, 150–5 (1955) In German.

A straightforward method is given for the derivation of the Zener formula for internal field emission in crystals which is particularly applicable to the limiting case when the width of the forbidden energy zone is small.

G. F. J. GARLICK

537.533.2

4720. Field emission from rhenium: emission pattern corresponding to hexagonal crystal structure. G. BARNES. *Phys. Rev.*, **97**, *No.* 6, 1579–83 (*March* 15, 1955).

Field emission patterns from a clean metal having the hexagonal crystal structure (rhenium) are photographed. The fabrication of rhenium needle-shaped cathodes having tip radii of the order of 5×10^{-5} cm is described, and electron microscope shadowgraphs of such emitters are shown. The use of a high-temperature flash in vacuum to smooth and clean the emitter is illustrated. Emission pattern detail is correlated with crystallographic structure; in particular, the crystal faces with low Miller–Bravais indices have reduced current density, resulting, it is assumed, from values of the work function which are higher than the average value. Rhenium is shown to be more resistant to work function change by oxygen adsorption than is tungsten by a direct comparison under identical experimental conditions. A.

537.533.3

4721. Electron optics of cylindrical systems with a plane of symmetry. I. First order approximation. M. LAUDET. *J. Phys. Radium*, **16**, *No.* 2, 118–24 (*Feb.*, 1955) In French.

Since the electromagnetic field of cylindrical systems with a plane of symmetry depends only on two variables, the electron trajectories in such cases may be derived using a Lagrangian treatment. Certain simple image-object relationships in a magnetic lens are obtained using first-order approximations. R. REED

537.533.35

4722. Preliminary attempts at phase contrast in electron microscopy. M. LOCQUIN. *Z. wiss. Mikr.*, **62**, *No.* 3, 220–3 (*Jan.*, 1955) In French.

Phase-contrast images are possible using electron beams. Phase separation is obtained in a magnetic lens using the electrostatic field set up by a point located in its focal plane. Image contrast and detail are greatly enhanced, though these effects have as yet been observed only with objects of extreme thinness and directly mounted without a supporting film.

R. REED

537.533.35

4723. A β-spectrometer with wide-angle double focusing. E. HUSTER, G. LEHR AND W. WALCHER. Note in *Z. Naturforsch.*, **10a**, *No.* 1, 83–4 (*Jan.*, 1955). In German.

The results of calculations on the focusing properties of a magnetic field with a specified radial dependence are given and compared with the results for the spectrometer of Hedgran *et al.* [Abstr. 8781 (1950)].

J. HUGHES

537.533.35 : 539.165

4724. Description and calibration of a beta-spectrometer with double focusing. The beta-spectrum of Cs^{137}. J. DEMUYNCK AND J. VERHAEGHE. *Meded. K. Vlaamse Acad. Wetensch.*, **16**, *No.* 11, 21 *pp.* (1954) In Flemish.

It is an instrument of the Svartholm and Siegbahn

type and the magnetic field was calibrated using proton resonance. Results obtained for Cs^{137} are given.

J. M. HOUGH

537.533.73/.74

4725. The diffraction and inelastic scattering of electrons. A. Ya. Vyatskin. *Zh. éksper. teor. Fiz.*, **27**, *No.* 2(8) 162–70 (1954) In Russian.

Theoretical. Diffraction and inelastic scattering of electrons in metals are considered as two interconnected parts of the single process of the passage of electrons through a metal lattice. The inelastic scattering arises from a Coulombic interaction between the diffracted electrons and the electrons of the lattice. The author establishes the existence of a strong influence of diffraction on inelastic scattering and of inelastic scattering on diffraction. J. A. SPINK

537.533.74

4726. Radiative corrections to electron scattering. R. G. Newton. *Phys. Rev.*, **97**, *No.* 4, 1162–75 (*Feb.* 15, 1955).

The techniques and results of a previous paper [Abstr. 8036 (1954)] are applied to the calculation of the second Born approximation of the one-photon radiative corrections to the scattering of electrons by nuclei. Non-relativistic and high-energy approximations are calculated explicitly for pure Coulomb scattering. Modifications due to the finite extension of the nucleus are discussed. No definite conclusion is reached concerning the change of the correction due to this extension, but it is shown that at extremely high energies the relative radiative correction to the second Born approximation is independent of the nature of the charge distribution. It is also shown that the fictitious zeros of the first Born approximation disappear first in the third Born approximation. The shape factor occurring there is briefly discussed. A.

537.533.74

4727. The nuclear scattering of electrons and positrons at 0·7 and 1·4 MeV. J. Ellis and C. Henderson. With an appendix describing the counting equipment. G. R. Heyland and P. W. Roberts. *Proc. Roy. Soc. A*, **229**, 260–71 (*April* 21, 1955).

An experiment is described in which electrons and positrons are scattered, under identical conditions, at energies of 0·7 and 1·4 MeV by foils of aluminium, silver and gold. Both the incident and scattered particles are counted by making use of the fast response and good energy resolution of anthracene crystals. The incident beam, which is in the form of a divergent hollow cone of semi-vertical angle of near 10°, and of 5% energy spread, is provided by using radioactive sources in a β-ray spectrometer. Effective angles of scattering of 22·8, 34·5 and 47·5° are employed. It is concluded that, within the experimental accuracy of about $\pm 5\%$, the results are in accordance with predictions of the Dirac theory. A.

537.533.74 : 539.172

4728. Scattering of 192-MeV electrons from the deuteron. J. A. McIntyre and R. Hofstadter. *Phys. Rev.*, **98**, *No.* 1, 158–61 (*April* 1, 1955).

Elastic scattering of 192 MeV electrons from deuterium has been studied using both solid (CD_2) and high-pressure gas targets. The results obtained by these two methods are in agreement and yield the following conclusions: (1) The range of the neutron-proton potential is between 1 and 4×10^{-13} cm if a square potential well is assumed and if the deuteron wave-functions predicted by the binding energy of the deuteron are used. (2) It is, however, impossible with the present data to eliminate the possibility of other charge distributions for deuterium such as uniform or Gaussian. Inelastic electron scattering from deuterium was also investigated, and promises to give independent information of the deuteron structure. A.

537.533.75

4729. Ranges of low-energy electrons in protein. M. Davis. Letter in *Nature* [*London*] **175**, 427–8 (*March* 5, 1955).

If a uniform layer of dry enzyme of thickness greater than the electron ranges concerned is irradiated with a sufficient number of electrons, all the enzyme within the range of the electrons is inactivated. The range can thus be deduced by assaying for activity remaining after irradiation. Ranges for electron energies from 100–2 000 eV have been measured: they are found to be significantly less than those calculated by Lea from the Bethe formula. D. V. MABBS

537.533.8

4730. Scintillation spectrometry of low-energy bremsstrahlung. M. Ehrlich. *J. Res. Nat. Bur. Stand.*, **54**, *No.* 2, 107–18 (*Feb.*, 1955).

A method was devised to measure bremsstrahlung spectra from commercial X-ray tubes of an absolute scale, using a thallium-activated sodium-iodide crystal-scintillation spectrometer. The method was used to study bremsstrahlung spectra between 20–100 kV exciting potentials from a beryllium window tube having a thick tungsten target. Fully corrected, absolute experimental spectra were obtained at exciting potentials of 50 and 100 kV. In order to compare the experimental results with theory, a calculation was made yielding the thick-target bremsstrahlung spectrum derived from Sommerfeld's theory. Experiment and theory showed order-of-magnitude agreement. However, a characteristic difference in spectral shape was observed, the experimental spectra showing a more pronounced peak. This peak is near 30 keV and gives the impression of being superimposed on the spectral shapes expected from theory. Finally, a point of interest to the practical user of the X-radiation from beryllium window tubes was brought out, namely, that a considerable portion of the low-energy radiation, at least in the region between 12 and 30 keV, is strongly absorbed in the tungsten target of a conventional X-ray tube. A.

537.533.8 : 621.385.833

4731. Nonsaturable high-energy beam monitor. G. W. Tautfest and H. R. Fechter. *Rev. sci. Instrum.*, **26**, *No.* 2, 229–31 (*Feb.*, 1955).

The monitor uses the phenomenon of secondary emission. The primary beam to be monitored passes through a set of foils alternately phased in voltage.

The current produced by secondary electrons ejected by the beam passage is collected on to the one set of foils and measured. Results of tests with high-energy electrons are given. The monitor gives no indication of saturation up to peak current densities of 16 mA/cm², and is independent of the primary beam energy in the range over which the monitor was tested (111–235 MeV). A.

537.534 : 621.384.62

4732. Berkeley proton linear accelerator. L. W. Alvarez, H. Bradner, J. V. Franck, H. Gordon, J. D. Gow, L. C. Marshall, F. Oppenheimer, W. K. H. Panofsky, C. Richman and J. R. Woodyard. *Rev. sci. Instrum.*, **26**, *No.* 2, 111–33 (*Feb.*, 1955).

This accelerator increases the energy of protons from a 4 MeV Van de Graaff injector to a final energy of 31·5 MeV. It consists of a cavity 40 feet long and 39 inches in diameter, excited at resonance in a longitudinal electric mode with a radiofrequency power of about $2{\cdot}1\times10^6$ W peak at 202·5 Mc/s. Acceleration is made possible by the introduction of 46 axial "drift tubes" into the cavity, which is designed so that the particles traverse the distance between the centres of successive tubes in one cycle of the r.f. power. The proton bunches are longitudinally stable as in the synchrotron, and are stabilized transversely by the action of converging fields produced by focusing grids. The electrical cavity is constructed like an inverted aeroplane fuselage and is supported in a vacuum tank. Power is supplied by 9 high-powered oscillators fed from a pulse generator of the artificial transmission line type. Output currents are 3×10^{-7} A, average, and 60 μA, peak. The beam has a diameter of 1 cm and an angular divergence of 10^{-3} radian. A.

537.534 : 621.384.62

4733. Proton linear-accelerator injector for the Bevatron. B. Cork. *Rev. sci. Instrum.*, **26**, *No.* 2, 210–19 (*Feb.*, 1955).

The Bevatron requires an intense source of high-energy protons. The machine should accept mono-energetic protons for a duration of approximately 500 μsec once every 6 sec. To satisfy the requirements of small loss due to scattering by the gas in the accelerating chamber, a 9·9 MeV linear accelerator has been built and operated. A 500 kV Cockcroft–Walton generator is used to inject 3 mA peak proton current into the linear accelerator. Focusing grids intercept approximately half of the injected beam. Additional losses, including radial defocusing and acceptance phase angle, result in a peak accelerated beam of 225 μA. The energy spread of the accelerated protons has not been measured, but an upper limit is less than $\pm$30 keV. A.

537.534 : 621.384.62

4734. Focusing in linear ion accelerators. L. Smith and R. L. Gluckstern. *Rev. sci. Instrum.*, **26**, *No.* 2, 220–8 (*Feb.*, 1955).

The results of the investigation of three methods of obtaining transverse stability in linear accelerators for ions are presented and discussed. For electric or magnetic quadrupole focusing the range of stable operation, oscillation amplitudes and the effect of perturbing errors are treated. For grid focusing, the operation of an actual grid is analysed from measurements of the field distribution. Finally, the formulae applicable to focusing by axial magnetic lenses are presented. A.

537.534.3 : 621.384.8

4735. An r.f. linear decelerator mass spectrometer. W. Donner. *Appl. Spectrosc.*, **8**, *No.* 4, 157–62 (*Nov.*, 1954).

The spectrometer is capable of resolution to mass 100. Ions are formed by electron impact in a somewhat conventional ion chamber, utilizing an electron beam at right angles to the ion beam, temperature regulation and pressure differential for high signal to background ratio. All of the ions are then accelerated through 2 500 V, collimated, and then passed through a series of 24 r.f. gaps, spaced such that the preferred (or resonant) particles are decelerated by an amount equal to the r.m.s. value of the r.f. voltage at each gap, all other particles emerging from the r.f. analyser with correspondingly higher energies. The resultant "energy dispersed" beam is then separated in an electrostatic deflection system, the preferred (lowest-energy) beam being collected in a Faraday bucket, and observed on a vibrating reed electrometer. A linear mass scan is achieved by varying the frequency applied to the gaps. A.

537.534.74

4736. Elastic *p-p* angular distribution 440–1 000 MeV. L. W. Smith, A. W. McReynolds and G. Snow. Letter in *Phys. Rev.*, **97**, *No.* 4, 1186–8 (*Feb.* 15, 1955).

Measurements of the angular distribution of elastic *p-p* scattering have been made at incident proton energies of 440, 590, 800 and 1 000 MeV. The two recoil protons were detected in two scintillation counter telescopes. Elastic *p-p* events were selected by requiring coincidence of the two telescopes when set at proper kinematic angles and with appropriate time delay. The scattering angle was defined to $\pm1/4°$. The spread in energy was $\sim\pm5\%$ and the uncertainty in the mean energy is taken to be half that. The elastic *p-p* cross-section falls only slightly in the region from 440 to 1 BeV. The facts that the ratio $\sigma_{total}/\sigma_{elastic}$ is close to two and that the angular distributions at 800 and 1 000 MeV are strongly peaked forward, suggest that the elastic *p-p* scattering is primarily a shadow-scattering associated with the strong "absorption" of the incident proton wave via meson production. D. R. Chick

537.534.74

4737. Elastic scattering of 20·6-MeV protons by deuterons. D. O. Caldwell and J. R. Richardson. *Phys. Rev.*, **98**, *No.* 1, 28–39 (*April* 1, 1955).

The absolute differential cross-section for the elastic scattering of 20·6 MeV protons by deuterons was measured by using the external beam of the U.C.L.A. synchrocyclotron. A triple-coincidence proportional counter telescope, with variable absorbers between the second and third counters and differential pulse-height discriminators (set by a new method) on the first two counters, was used to select the desired particle by range and specific ionization. Deuterium gas at atmospheric pressure provided the target for the proton beam, which was collimated to $\frac{1}{8}$ in. diameter, with a maximum angular divergence of $\frac{1}{2}°$.

An interchangeable slit system gave angular resolutions of 0·9° or 1·8°. Absolute measurements were made at 22 angles from 12° to 164° (centre-of-mass) with an accuracy varying approximately from 1% to 3%, depending upon the angle. The cross-section shows the familiar deep minimum (near 130° in the present case), but in addition a shallower minimum near 18°, due to Coulomb-nuclear interference. This latter minimum should allow fitting the data with a unique set of phase shifts, unlike previous nucleon-deuteron scattering experiments, and thus provide a more stringent test for theories. A.

537.534.74

4738. Elastic scattering of 9·76-MeV protons by helium. J. H. WILLIAMS AND S. W. RASMUSSEN. *Phys. Rev.*, **98,** *No.* 1, 56–7 (*April* 1, 1955).

The differential cross-section for elastic scattering of 9·76 MeV protons by helium has been investigated over the range of centre-of-mass angles from 43° to 174°. The results are in essential agreement with those of Putnam at 9·48 MeV, differ from those by Freemantle *et al.* at 9·55 MeV by a constant factor, but do not confirm those of Cork and Hartsough at 9·7 MeV. A.

537.534.74

4739. Relation between multiple Coulomb scattering and residual range in nuclear emulsion. R. G. GLASSER. *Phys. Rev.*, **98,** *No.* 1, 174–80 (*April* 1, 1955).

Measurements of multiple Coulomb scattering were carried out on 101 artificially produced stopping protons from the end of the track to a point where the residual range was 2 500μ. These measurements yield a new relation between range and multiple scattering which can be represented by a power law. The mass dependence was derived theoretically and checked by measuring 20 positive pions. The general relationship is:

$$\langle|\eta|\rangle_{Av} = (19{\cdot}0 \pm 0{\cdot}3)R^{-(0{\cdot}607 \pm 0{\cdot}016)} (M_P/M)^{(0{\cdot}393 \pm 0{\cdot}016)}(t/50)^{\frac{1}{2}},$$

where $\langle|\eta|\rangle_{Av}$ is the mean absolute sagitta due to multiple scattering, R is the range, t the cell length, M is the particle mass and M_P the mass of the proton. All lengths are measured in microns. This relationship leads to a set of schemes for making scattering measurements on stopping tracks in order to determine the mass of the particle with the maximal efficiency. The precision possible on an individual track is limited, but a sequence of tracks, each of which need not be too long, can give a very satisfactory precision, free from the systematic errors inherent in ionization measurements. A.

537.534.74 : 778.34

4740. Measurement of the scattering constant in nuclear emulsion. L. W. SMITH. *Phys. Rev.*, **98,** *No.* 1, 100 (*April* 1, 1955).

The general solution to the diffusion equation is used to show that a measurement of track-to-track scattering of identical particles yields a value of the scattering constant in an unambiguous manner. A.

537.534.75

4741. Range of 208 ± 4-MeV protons in *G5* nuclear emulsion. H. G. DE CARVALHO AND J. I. FRIEDMAN. *Rev. sci. Instrum.*, **26,** *No.* 3, 261–3 (*March*, 1955).

A range curve of the external beam of the University of Chicago synchrocyclotron was taken in G5 stripped nuclear emulsion. The range of this beam in copper was also measured in order to determine its energy. Having a mean range of 41·1 ± 0·1 g/cm² of copper, the beam had an energy of 208 ± 4 MeV according to Aron's tables. The mean range of the same beam in *G5* nuclear emulsion at 47% relative humidity was 41·3 ± 0·2 g/cm² which is about 1·2% longer than that from Heinz's measurements and about 1·3% shorter than that calculated by Vigneron. At 47% relative humidity the average density of the emulsion was measured to be 3·85 ± 0·01 g/cm³, in good agreement with the calculations of Wilkins. A.

537.534.75 : 778.34

4742. Morphological study of $_6C^{12}$ tracks in nuclear emulsions. P. CÜER, J. P. LONCHAMP AND C. GEGAUFF. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 8, 856–8 (*Feb.* 21, 1955) In French.

The variation in the thickness of 120 MeV C^{12} tracks in G5 nuclear emulsions was studied. A rapid increase in thickness is observed up to 45μ, and a slower increase up to 140μ and perhaps further. P. ROTHWELL

537.534.79

4743. The electrical mass filter. W. PAUL AND M. RAETHER. *Z. Phys.*, **140,** *No.* 3, 262–73 (1955) In German.

A principle for determining e/m for ions suggested by Paul and Steinwedel [Abstr. 2502 (1954)] which can be used for isotope separation and ion mass analysis is explained and experimentally examined. Ion orbits in a.c. quadrupole fields have stable and unstable regions as a function of e/m. In the unstable regions the ion oscillation amplitude grows very large after a number of periods. Only ions remaining near the symmetry axis of the field are collected so that the arrangement can be used as a mass filter. The filter action is discussed with reference to the equations of motion which are of Mathieu's type. The stability regions can be narrowed by using d.c. as well as a.c. fields. Experimentally, Ru isotopes 85, 87 were successfully separated and the abundance ratio determined with 3% accuracy. Ion currents of the order of microamperes were used and an ion yield of 10% could be obtained when the mass resolving power $m/\Delta m$ was 55. Increasing the resolving power by a factor 5 reduced the yield to 10^{-4}. Sources of errors are discussed. H. MOTZ

537.534.9

4744. Measurements and collision–radiation damage theory of high-vacuum sputtering. F. KEYWELL. *Phys. Rev.*, **97,** *No.* 6, 1611–19 (*March* 15, 1955).

A brief summary of some of the important experimental and theoretical work related to the subject of metallic sputtering is presented. The need for measurements in high vacuum is indicated and an ion beam which utilized a Philips Ion Gauge discharge ion source to make high-vacuum sputtering ratio measurements is described. Absolute sputtering ratio data for the gas-metal combinations Ag–Kr, Ag–A, Ag–Ne, Ag–He, Cu–Kr, Cu–A, Pb–A and Pb–He are presented in terms of the number of atoms sputtered per incident ion, n_a, v. incident ion energy, E_0, for ion energies varying between 400–6 100 eV.

The data are interpreted by treating the incident ion as a hard sphere which "cools" in a manner similar to a neutron losing energy by collisions in a lattice, each collision producing recoil atoms and atomic displacements near the surface. The number of atoms escaping, or "sputtering," from the metallic surface is reduced from the number displaced by absorption within the metal which is accounted for by a parameter α. By use of elementary neutron cooling theory and the Seitz formula for displacements produced by a recoil atoms within a solid, the formula for the number of atoms sputtered per incident ion is given by

$$n_a = \left(\frac{\varepsilon E_0}{E_d}\right)^{\frac{1}{2}} \sum_{n=1}^{n_c} e^{-\alpha\sqrt{n}e^{-(n-1)\xi/2}}, n_c = \frac{1}{\xi}\ln\left(\frac{\varepsilon E_0}{E_d}\right),$$

when the ions are more massive than the metallic atoms. The effect of ions rebounding from the surface after the first collision is considered to produce effectively two types of incident current particles: (1) incident gas ions and (2) recoil metal atoms. These considerations lead to a modified sputtering ratio formula, which reduces to the above equation when $M_1 \geqslant M_2$. The displacement energy for the process, E_d, is calculated by use of G. K. Wehner's data on sputtering thresholds and the relation $E_t = E_d/\varepsilon$. A fair fit to the experimental data is obtained by suitable choice of α in the modified formula for the cases studied. The use of "hard" collisions is justified and an equivalent ion energy shift defined by equal average energy transfer on the first ion-atom collision is applied to the data. The subject of sputtering thresholds is treated by an attempt to bracket observed thresholds, E_t, between limits defined by the atomic heat of vaporization, the displacement energy, and the average energy transfer per collision. A.

DISCHARGE TUBES . COUNTERS 537.54

537.542

4745. A model of a magnetic-field type deuteron source. G. Perona and A. Persano. Letter in *Nuovo Cimento* (*Ser.* 10) **1,** *No.* 3, 501–3 (*March*, 1955) In Italian.

Describes an ion source designed for use with the 400 keV C.I.S.E. accelerator. Graphs are given showing the variation of the ion current with magnetic field, anode current and extraction voltage for continuous and for pulsed operation. P. ROTHWELL

537.542 : 621.387

4746. Low-frequency dynamic response of photosensitive neon discharge tubes. T. J. Dillon. *Brit. J. appl. Phys.*, **6,** *No.* 4, 138–40 (*April*, 1955).

The instantaneous response to illumination of photosensitive discharge tubes in relaxation oscillation circuits has been investigated, using light sources of periodically varying light output to irradiate the tubes. A brief theoretical outline is given of the effect of periodic variations on saw-tooth oscillations and this is applied to the oscillations of neon discharge tubes illuminated by sources giving a light output of rectified sinusoidal waveform. Photographs are given of oscillation traces of tubes illuminated by light from mercury vapour lamps and by intermittent light pulses. It is shown that, under certain conditions, a complete delineation of the light output waveform is obtained. This method can be used for the determination of the light variation frequency or for studying the waveform of the light output from a source. A.

537.542

4747. A 4π proportional counter for the investigation of nongaseous, low-energy β-emitters with complex decay schemes. W. Beckmann and E. Huster. Note in *Z. Naturforsch.*, **10a,** *No.* 1, 85–6 (*Jan.*, 1955) In German.

This is briefly described and graphs are given of the results obtained with a source of RaD. J. HUGHES

537.542

4748. On the measurement of recovery times of Geiger–Müller counters at the Geiger threshold. D. Blanc. Letter in *Nuovo Cimento* (*Ser.* 10) **1,** *No.* 3, 504–6 (*March*, 1955) In French.

Describes measurements of recovery times for Geiger counters with external and internal cathodes. The results are used to estimate the mobilities of various positive ions. J. D. CRAGGS

537.542

4749. A thin, wide-aperture proportional counter. R. M. Eisberg and H. E. Wegner. Letter in *Rev. sci. Instrum.*, **25,** *No.* 11, 1129 (*Nov.*, 1954).

Describes an assembly composed of a honeycomb arrangement of small counters, each with a cathode wire and an anode composed of six wires. In an area $3\frac{1}{2} \times \frac{7}{8}$ in. there are fifteen such counters. Tests were made, with an α-particle source, using a 1 atm. A–70%CO_2 filling at 1 700 V. J. D. CRAGGS

537.542

4750. Proportional flow counter with high-humidity gas. G. Nilsson and G. Aniansson. *Nucleonics*, **13,** *No.* 2, 38–9 (*Feb.*, 1955).

Good plateaux have been obtained in windowless proportional counters used in counting particles from surfaces of aqueous solutions. This is made possible by the use of counting gases having ionization potentials lower than that of water, in which case charge transfer from H_2O^+ ions to the gas molecules takes place. The gases used successfully included methane, ethane, propane and acetylene.

L. R. SHEPHERD

537.542

4751. Very wide-range absorption counting system. W. H. Baker, M. L. Curtis, L. B. Gnagey, J. W. Heyd and J. S. Stanton. *Nucleonics*, **13,** *No.* 2, 40–3 (*Feb.*, 1955).

The system described consists of a windowless proportional counter used in conjunction with an amplifier capable of handling pulses having a wide range of amplitude and width. A wide range of absorbers from $10\mu g/cm^2$ to $75 mg/cm^2$ can be mounted between the active sample and the counter volume. The method of forming $10–100\mu g/cm^2$ plastic films and the use of Al electroscope foils to provide absorbers in the range $150–900\mu g/cm^2$ are described. L. R. SHEPHERD

537.542

4752. A modified pocket integrating ion chamber type B.D.11 of nearly uniform polar response. B. W. SOOLE. *J. sci. Instrum.*, **32**, *No.* 4, 144–5 (*April*, 1955).

The pocket ionization chamber type B.D.11 as developed by the Medical Research Council for personnel protection is shown to be less sensitive to γ-radiation received along its axis than to radiation received in a perpendicular direction. By reducing the overall length of the chamber from 46·5 to 32·5 mm the chamber may be made equally sensitive in all directions, excepting that long its axis through the screw. A.

537.542

4753. Scintillation counting for multiple-tracer studies. G. J. HINE, B. A. BURROWS, L. APT, M. POLLYCOVE, J. F. ROSS AND L. A. SARKES. *Nucleonics*, **13**, *No.* 2, 23–5 (*Feb.*, 1955).

The use of well-type scintillation counters to measure the intensities of two radioisotopes, present together in the same sample, is discussed with reference to mixtures of Cr^{51} with Fe^{59} and K^{42} with Na^{24}. The analysis of the radiations from the former can be accomplished by pulse height discrimination with a NaI(Tl) detector. In the other case, it is necessary to compare counting rates in a NaI(Tl) detector with those in a plastic scintillator which has different relative efficiencies for the two activities.

L. R. SHEPHERD

537.542 : 539.164.08

4754. The resolution of alpha-particle spectra by ionization pulse analysis of collimated samples. D. W. ENGELKEMEIR AND L. B. MAGNUSSON. *Rev. sci. Instrum.*, **26**, *No.* 3, 295–302 (*March*, 1955).

A high-resolution ion pulse analyser has been developed for the study of α-decay fine structure. Alpha-particle spectra are distorted in conventional high-geometry measurements by addition of ionization from excited-state radiations of the daughter atom. Covering the sample foil with electroformed nickel mesh of a few mils thickness proved to be an effective technique for collimating the α-particles and absorbing coincident excited-state radiations. The resolution of the instrument was tested with samples of Bi^{212}, Th^{230} and Pu^{238}. The measured intensities and particle energies are in satisfactory agreement with magnetic deflection data. Alpha-peak standard deviations of 12–13 keV were obtained at a detection efficiency of 0·04 count per disintegration. The standard deviation due to amplifier noise alone amounted to 10 keV. A.

537.542 : 621.374.32

4755. Statistics of the Glass–Hurst pulse integrating circuit. J. F. PERKINS. Letter in *Rev. sci. Instrum.*, **26**, *No.* 1, 88–9 (*Jan.*, 1955).

Glass and Hurst [Abstr. 3656 (1952)] have investigated experimentally the increase in σ in a particular case consequent upon the use of discriminators only at the input to each stage of a simplified pulse integrator. The general case is investigated here. The standard deviations arising from the random nature of the order of the pulses and from their time separation are each calculated and combined to give a measure of the additional uncertainty introduced by the omission of anti-coincidence circuits. S. C. DUNN

537.542 : 621.374.32

4756. A direct reading analyzer for short time intervals. G. K. O'NEILL. *Rev. sci. Instrum.*, **26**, *No.* 3, 285–90 (*March*, 1955).

A time-analyser with nine 4·6 μsec channels has been developed. It is based on the chronotron principle but presents data directly on mechanical registers. The device is compact, stable and easy to adjust. Variation of channel boundaries is less than 5×10^{-10} sec over long periods. Construction is such that changes in the time scale can be made, and even narrower channel widths should be possible. The principle is applicable to analysers of more than nine channels. A.

537.542

4757. Automatic registration of particle tracks in the continuous diffusion cloud chamber. I. B. LALOVIĆ, A. B. MILOJEVIĆ AND M. A. CERINEO. *Bull. Inst. Nuclear Sci. "Boris Kidrich,"* **4**, 97–103 (*June*, 1954).

A method has been developed in which a photomultiplier tube is used for the automatic registration of the passage of individual particles through the sensitive region of the diffusion chamber, and for the triggering of the photographic system. In over 80% of the photographs taken using this method, the tracks which trigger the automatic system are identifiable. Some further investigations were made on the working conditions of the diffusion cloud chamber with different vapours and at different temperature intervals. P. ROTHWELL

537.542 : 537.591

4758. The high-pressure cloud-chamber cosmic-ray programme at La Marmolada. *Nature* [*London*] **175**, 445–8 (*March* 12, 1955).

Gives a short description of a high-pressure chamber (~75 atm.) now in operation at an altitude of 2020 m. Examples are given of photographs showing the decay of θ^0- and V^0-particles and of stars produced in the gas of the chamber. The present chamber is not operated in a magnetic field but a second chamber is being built to work in a magnetic field of 10000 gauss. H. ELLIOT

IONIZATION . THERMIONICS 537.56/.58

537.56

4759. Negative ion studies with the mass spectrometer. J. MARRIOTT AND J. D. CRAGGS. *Applied Mass Spectrometry Conference Report*, 173–184 [see Abstr. 5066 (1955)].

Experiments were carried out in order to provide information on the structure of some molecules and on the dissociation patterns for negative and positive ion formation in complex polyatomic molecules. As the negative or related positive ion mass spectra may contain several ion species, mass analysis with a mass spectrometer was indicated. By the use of a Lozier type ionization apparatus it is possible to evaluate the minimum kinetic energy which the fragments

possess at the critical potential. Appearance potentials of negative ions were specially investigated. Negative ions which are found at low energies present special problems, as the energy scales fixed at higher energies will not be valid in this region. Such cases were examined. Measurements of the relative abundances of negative and positive ions were also carried out, but the variation of electric current with electron energy is not satisfactory below 10 eV. A. J. TAYLOR

537.562

4760. Negative ion formation in gases of high dielectric strength. J. MARRIOTT AND J. D. CRAGGS. *Rep. Brit. Elect. Res. Assoc., Rep. L/T*301, 38 (1953).

Gives a general discussion of the effect of attachment processes on the breakdown criteria in gases, with a collection of data on relative values of dielectric strength. Following this, an account is given of preliminary studies with a mass spectrometer of collision processes in various attaching gases. The latter include $SiCl_4$ and SF_6, and new data for $GeCl_4$, CF_3Br and CF_3I are given. J. D. CRAGGS

537.562

4761. Negative ion formation in gases of high dielectric strength. II. The Lozier apparatus. J. MARRIOTT AND J. D. CRAGGS. *Rep. Brit. Elect. Res. Assoc., Rep. L/T*308, 16 *pp.* (1954).

Describes in detail the construction, adjustment and calibration of a Lozier ionization apparatus, used for the study of collision processes involving negative ions, in various molecular gases. Preliminary results are given for oxygen (as a calibration check) and CCl_4. J. D. CRAGGS

537.563

4762. Applications of field ionization to mass spectrometry. R. GOMER AND M. G. INGHRAM. Letter in *J. Amer. Chem. Soc.*, **77**, *No.* 2, 500 (*Jan.* 20, 1955).

Extension of previous work [Abstr. 9309 (1954)]. A table is given of the ion yields from various gases with the tungsten field ionization source. The applications suggested are: analysis of gas mixtures, determination of transient intermediate radicals in photochemical, thermal or radiation processes and the investigation of fragmentation occurring on metal catalyst surfaces. J. HUGHES

537.563

4763. The mass spectrum of lithium iodide. L. FRIEDMAN. *J. chem. Phys.*, **23**, *No.* 3, 477–82 (*March*, 1955).

The mass spectrum of lithium-iodide vapour produced from salt heated in an oven in the ion source of an analytical mass spectrometer was investigated as a function of oven temperature. Evidence was obtained for the existence in the vapour of both monomer and dimer. Partial heats of sublimation to monomer and dimer at 0°K were found to be $44{\cdot}9 \pm 0{\cdot}7$ and $45{\cdot}5 \pm 2$ kcal respectively. The heat of dissociation of $(LiI)_2$ into gaseous monomers was found to be $44{\cdot}4 \pm 2{\cdot}2$ kcal. The partial heat of sublimation of monomer was used with supplementary thermochemical data to obtain values for the lattice energy and the heat of dissociation of the diatomic molecule. Appearance potentials for the major ions in the spectrum where determined. Upper limits for the energy of dissociation of the gaseous diatomic molecule were derived from the appearance potentials of Li^+ and I^+ which were slightly higher than the thermochemical value. A.

537.564

4764. Ionization in pure gases and the average energy to make an ion pair for alpha and beta particles. W. P. JESSE AND J. SADAUSKIS. *Phys. Rev.*, **97**, *No.* 6, 1668–70 (*March* 15, 1955).

A series of measurements has been made of the relative currents produced in different gases by β-particles from Ni^{63} and from tritium sources in an ionization chamber. In all cases only relative current measurements with argon as a standard gas have as yet been made. The value of W, the average energy to make an ion-pair computed relative to argon as a standard, is found to be the same for Ni^{63} and tritium sources. If these relative W_β values are plotted as abscissas against previously determined W_α values for polonium α-particles as ordinates, a marked difference is observed in the gases investigated. For hydrogen and the noble gases the plotted points lie closely on a 45 degree straight line through the origin. Thus for these gases the ratio W_α/W_β is constant. This constant may well be unity, but this is not proved as yet by these results. For all other gases so far investigated, the plotted points lie above the 45 degree line, indicating a higher efficiency of ionization (and a lower W) for the β-particles than for the polonium α-particles. These results are in accord with the findings of Gray and Gurney. Gurney's results have been extended here to include a greater variety of gases for reduced α-particles of approximately 1 MeV energy. Two postulates are advanced to explain the behaviour of W_α and W_β here found. A.

537.564 : 523.872

Collisions between protons and metastable atoms or ions having outer p^q shells. *See Abstr.* 4320

537.583

4765. Breakdown of the Boguslavskiĭ–Langmuir law during the heating of the tungsten cathode of a vacuum lamp by a pulse of current of great density. S. V. LEBEDEV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 4(10), 487–500 (1954) In Russian.

The basic unit in these expts. was a glass vessel, continuously pumped to approx. 2×10^{-6} mm Hg, with a W wire cathode across the middle, length 1 cm, dia. 0·1 mm, and two plates 0·5 cm^2 distant 1 cm on opposite sides of the cathode serving as anode and collector. With increase of static cathode heating current (limited by m.pt. of W) I_a increased for a while and thereafter only negligibly, due to space-charge, in conformity with the B. L. law. Heating cathode by heavy current pulse obtained by discharge of a bank of condensers (5 kV, $3{\cdot}4\times10^6$ A/cm^2) gave values of I_a hundreds of times greater than those obtained under stationary conditions. Further expts. show that after switching on current pulse I_a remains for a time on the plateau value expected from the B. L. law but the duration of plateau decreases with increase of voltage across cathode. It is suggested that after the cathode heater current pulse has been applied for a time (say, 10^{-5} sec) the cathode is in an anomalous state giving anomalously high emission—of order 100× near the fusion point of the W cathode. C. R. S. MANDERS

537.583 : 621.385.032.216

4766. Background noise of oxide cathodes. J. DALBERT. *Vide*, **9**, 200–2 (*July–Sept.*, 1954) In French.

The increase in equivalent noise resistance at frequencies <100 kc/s is described and its relation to cathode temperature, saturation current, current density, space current discussed in general terms. This increment goes through a minimum for a cathode current much less than the nominal working value. The value of the minimum is a function of frequency and varies from sample to sample. A table of R_{eq} is given for a number of common pentodes and triodes. S. C. DUNN

COSMIC RAYS 537.591

537.591.1

4767. The flux of primary cosmic ray nuclei of atomic number $Z \geqslant 2$ at geomagnetic latitude 30°. B. PETERS. *Proc. Indian Acad. Sci. A*, **40**, *No.* 6, 230–48 (*Dec.*, 1954).

The method of determining the primary flux of nuclei with atomic number $Z \geqslant 3$ developed by Bradt and Peters, has been extended to include all nuclei of charge $Z \geqslant 2$. It is shown that the method permits the identification of primary helium nuclei with an efficiency $\eta \geqslant 90\%$. The primary α-particle flux obtained in this way is in very good agreement with that obtained by other methods and the relative flux values for nuclei of atomic number $3 \leqslant Z \leqslant 5$ and $6 \leqslant Z \leqslant 9$ agree with previous determinations. A.

537.591.1

4768. Measurements of the intensity of neutrons in the cosmic radiation, at great depths under water. E. M. BINGGELI. *Helv. phys. Acta*, **28**, *No.* 1, 3–23 (1955) In French.

The flux of neutrons produced by cosmic rays at various depths under water (in Lake Geneva) has been measured using boron- and lithium-loaded photographic plates, surrounded by paraffin. The results obtained with the two types of emulsion are in agreement; in the range measured (12 metres to 302 metres under water) the flux ϕ_p at depth P metres is found to be given by the expression $\phi_p = \phi_0 \exp(-\gamma P)$, where $\phi_0 = 38 \pm 13$ neutrons/cm^2.j and $\gamma = (5{\cdot}4 \pm 0{\cdot}4)\%$, corresponding to a mean free path $\lambda = 185 \pm 15$ metres of water. P. ROTHWELL

537.591.1

4769. Scintillation counter study of energy spectra of cosmic-ray photons and electrons at 11 200 feet. C. N. CHOU AND M. SCHEIN. *Phys. Rev.*, **98**, *No.* 1, 162–4 (*April* 1, 1955).

An apparatus designed to measure cascade showers initiated by photons and electrons of energies in the range of 1 BeV to 30 BeV was used to measure the energy spectra of cosmic-ray photons and electrons at Climax, Colorado (altitude 11 200 feet). The apparatus consisted of four anthracene-in-polystyrene plastic scintillators, interposed with 2·00 cm, 2·25 cm and 2·25 cm of lead plates, respectively. Four trays of G.M. counters and a set of anti-coincidence G.M. counters were used simultaneously with the scintillators. More than 10 000 events were recorded and analysed. The results show that in the energy range 2 to 20 BeV, the integral energy distributions can be represented by a power law expression of the form $N(>E) = \text{const}\ E^{-s}$, with s equal to $1{\cdot}6 \pm 0{\cdot}2$ for the photon component and s equal to $1{\cdot}5 \pm 0{\cdot}2$ for the electron component. A.

537.591.1

4770. Čerenkov counter flux measurement of cosmic-ray alphas at 41°. N. HORWITZ. *Phys. Rev.*, **98**, *No.* 1, 165–72 (*April* 1, 1955).

A Cherenkov counter inside a Geiger counter telescope was flown by balloon to a residual atmospheric depth of 16 g/cm^2. The purpose of the experiment was to measure the flux of cosmic-ray α-particles and to investigate the usefulness of a Cherenkov counter for flux measurements on the more heavily charged cosmic-ray components. A Cherenkov counter was used because of its inherent discrimination against slow secondary particles. The pulse height distribution obtained showed a partially resolved peak at approximately 4 h_0, where h_0 is the mean pulse height corresponding to a fast proton. This is experimental confirmation of the Z^2 dependence for Cherenkov radiation. There were 3 024 events which gave pulse heights corresponding to alphas. There is evidence that 451 were due to side showers, 651 were due to nuclear interactions, an additional 478 were due to either side showers or interactions, and 1 444 were due to primary alphas. This leads to the value 99 ± 16 particles/m^2-steradian-second, as the extrapolated flux at the top of the atmosphere. There is also an indication of peaks corresponding to carbon and oxygen. There is evidence that the geometry factor of the telescope was appreciably increased for the heavy components due to the action of δ-rays. A.

537.591.15

4771. Influence of the geomagnetic field on extensive air showers. P. CHALOUPKA. Letter in *Czech. J. Phys.*, **4**, *No.* 4, 508 (*Nov.*, 1954).

537.591.5

4772. Latitude effect of cosmic radiation at low altitudes. M. A. POMERANTZ. *Phys. Rev.*, **98**, *No.* 1, 105–6 (*April* 1, 1955).

The latitude effect, $L = 1 - [N(\lambda_2)/N(\lambda_1)]$, where $N(\lambda_1)$ is the intensity at $\lambda_1 > 40°$ and $N(\lambda_2)$ is the intensity at low latitude λ_2, has been determined on the basis of absolute flux measurements at two ground stations in India. Near sea level, $L = 8{\cdot}8 \pm 0{\cdot}6\%$ ($\lambda_2 = 18°$ N). At an atmospheric depth of 770 g/cm^{-2} $L = 13{\cdot}1 \pm 0{\cdot}6\%$ ($\lambda_2 = 23°$ N). At low altitudes (up to 30 000 ft) the latitude effect with respect to the geomagnetic equator in Peru is equal to that with reference to 18° N in India as expected on account of the eccentricity of the terrestrial dipole. A.

537.591.5

4773. Recurrence phenomenon in the 24-hour variation of cosmic-ray intensity. R. P. KANE. *Phys. Rev.*, **98**, *No.* 1, 130–5 (*April* 1, 1955).

Changes of cosmic-ray intensity in 24-hour intervals were studied at four neutron monitor stations and for one ionization chamber in the geomagnetic latitude range 0–52° N. There is evidence that the

fluctuations in the 24-hour variation of cosmic-ray intensity have a recurrence tendency of 27–28 days. There does not appear to be, however, any unique relationship between this recurrence and the well-known recurrence in the amplitude of the mean daily intensity. The association of this phenomenon with 27 day recurring disturbances in the geomagnetic field is also investigated. A.

537.591.8

4774. Neutron production due to penetrating cosmic rays in heavy material behind carbon. H. M. Weiss. *Z. Naturforsch.*, **10a**, *No.* 1, 21–32 (*Jan.*, 1955) In German.

Lead sheets of 1 and 2 cm thickness are placed behind carbon, and the neutron production in the lead is measured as a function of the thickness of carbon, at 445 metres altitude. A maximum occurs for 14 g/cm^2 carbon, coinciding with the appearance of a maximum in star production in photographic plates behind carbon [Abstr. 1100 (1952)]. It is indicated that this effect cannot be explained as being produced by known cosmic-ray components. G. E. BROWN

537.591.8

4775. Mass spectrum of shower particles from cosmic ray-interactions. A. Husain and E. Pickup. *Phys. Rev.*, **98**, *No.* 1, 136–9 (*April* 1, 1955).

The masses of particles with an ionization less than about twice the minimum value emitted in cosmic-ray stars in a photographic emulsion have been determined by observations on the grain density and scattering of suitably long tracks. About 100 tracks with an average length of 16·5 mm were analysed using a single emulsion exposed to cosmic rays in a high-altitude balloon flight of nine hours' duration. The results show groups of pions, protons, deuterons, heavy mesons with mass $\sim 925 m_e$ and the possibility of a group with mass closer to that of the proton. This latter is uncertain, however, with the present resolution and could be a statistical fluctuation on the edge of the proton distribution. A.

MAGNETISM 538

538.082

4776. A probe for the study of magnetic fields. R. Birebent. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 10, 1064–5 (*March* 7, 1955) In French.

The probe consists of a small search coil carrying a.c. and ultimately attached to a piezoelectric crystal whose output voltage, suitably amplified, gives a measure of the magnetic field acting on the coil. Direct and alternating fields between 75 and $1{\cdot}5 \times 10^4$ oersted are measurable by the instrument described.

E. P. WOHLFARTH

538.1 : 532.5

4777. Fundamental wave functions in an unbounded magneto-hydrodynamic field. I. General theory. A. Baños, Jr. *Phys. Rev.*, **97**, *No.* 6, 1435–43 (*March* 15, 1955).

This is the first of two papers dealing with a systematic study of the linearized, unbounded medium problems in magneto-hydrodynamics of incompressible and compressible fluids. Pt I deals with the fundamental equations which are set up quite generally for an ideal, homogeneous and isotropic, conducting fluid devoid of viscosity and expansive friction, subject only to the initial assumption that the externally applied field of magnetic induction be constant and uniform. The energy and momentum balance in a magneto-hydrodynamic field is verified with the aid of the exact fundamental equations and the conservation laws of energy and momentum, for a rigid volume fixed in the (stationary) observer's inertial frame of reference, are displayed in differential and in integral form. By successive eliminations there is obtained a single partial differential equation in the particle velocity from which the unwanted second-order terms are merely dropped in a linearized small amplitude theory, a process which is fully justified by considering the special case of infinite conductivity, zero displacement current, and incompressible fluids. Also, assuming that a particular solution of the linearized magneto-hydrodynamic wave equation has been obtained, it is shown how to compute quite generally, from the linearized Maxwellian set, the accompanying electromagnetic field vectors expressed in terms of the assumed velocity field. These computations are carried out for plane homogeneous waves and for time-harmonic cylindrical waves. The actual determination of particular wave-functions appropriate for incompressible and compressible fluids, together with the computation of the corresponding wave numbers, is reserved for Pt II. A.

538.114

4778. On the connection between the coercive force of a ferromagnetic and internal stress. F. Vicena. *Czech. J. Phys.*, **4**, *No.* 4, 419–38 (*Nov.*, 1954) In Russian, with summary (3 pp.) in English.

An extension of the internal stress theory of Néel. Account is taken of the spatial and angular distribution of the internal stresses, the regions of homogeneous stress being taken to be spherical and the angular distribution to be isotropic. Both boundary surface tension and internal magnetic pole effects were considered, the former effect being found to be much more important than was found by Néel, especially for iron where it predominates. With an internal stress of magnitude 30 kg.mm^{-2} the observed coercive force of iron (~1 oersted) and nickel (~10 oersted) can be accounted for; minimum values due to magnetostrictive stresses may also be derived.

E. P. WOHLFARTH

538.114

4779. Electromagnetic effects of spin wave resonance in ferromagnetic metals. W. S. Ament and G. T. Rado. *Phys. Rev.*, **97**, *No.* 6, 1558–66 (*March* 15, 1955).

It was shown experimentally by Rado and Weertman that under suitable conditions there is an observable effect of exchange interactions on the ferromagnetic resonance in metals. The present paper provides an electromagnetic theory of this "spin-wave resonance" experiment and satisfactorily explains the exchange shift as well as the width and shape of the absorption line. A combined solution is obtained of Maxwell's equations and the equation of

motion of the magnetization vector **M**, the latter equation including the exchange term due to the non-uniform orientation of **M** in the skin depth. It is shown that the triple refraction caused by the exchange effect necessitates the introduction of new boundary conditions. The final result, which is checked numerically and by an approximate calculation, is an expression for the measurable surface impedance and the "equivalent isotropic permeability" derived therefrom. This result is discussed and generalized, the properties of thermal spin waves in metals are briefly considered, and previous theories of exchange effects in ferromagnetic resonance are shown to be inadequate. A.

538.114 : 538.639

4780. The theory of the Nernst effect of ferromagnetic metals. K. MEYER. Note in *Z. Naturforsch.*, **10a**, *No.* 2, 166 (*Feb.*, 1955) In German.

The ratio of the extraordinary to the ordinary Nernst coefficients is shown on the basis of a two-band model and the treatment of Karplus and Luttinger [Abstr. 10366 (1954)] to be of the same order as the ratio of the corresponding Hall coefficients.

E. P. WOHLFARTH

538.12 : 538.52

4781. A screened homogeneous magnetic field. E.-G. SCHLOSSER. *Z. angew. Phys.*, **7**, *No.* 2, 59–61 (1955) In German.

Describes an arrangement of Helmholtz coils enclosed symmetrically in a cylindrical box, closed at both ends and made of Mumetal. It was found possible to reduce to zero all the derivatives $(d^nH/dx^n)_{x=0}$ up to $n = 7$, and the dimensions for optimum homogeneity at the centre of the system are derived. E. P. WOHLFARTH

538.221

4782. The preparation of very pure iron and the evaluation of its purity according to some physical properties. J. BEDNÁŘ, J. BROŽ, K. ŠMIROUS AND Z. TROUSIL. *Czech. J. Phys.*, **4**, *No.* 3, 345–9 (*Sept.*, 1954).

Pure iron has been prepared by electrolysis of ferrous chloride as well as by reduction of ferric oxide. The material thus obtained was refined in solid state by moist hydrogen. Its magnetic and electrical properties were measured and its thermal conductivity determined. By comparing the data gained in this way with the data obtained by other authors conclusions about the purity of this iron are drawn. A.

A comment on the work on pure iron. F. VICENA. *Ibid.*, **5**, *No.* 1, 105–6 (*Feb.*, 1955).

Reply to the comment on the work on pure iron. J. BEDNÁŘ, J. BROŽ, K. ŠMIROUS AND Z. TROUSIL. *Ibid.*, **5**, *No.* 1, 107–9 (*Feb.*, 1955).

On the question of very pure iron. L. ŠPAČEK. *Ibid.*, **5**, *No.* 1, 110–11 (*Feb.*, 1955) In Russian.

538.221

4783. Wall effects on microwave measurements of ferrite spheres. E. G. SPENCER AND R. C. LECRAW. Letter in *J. appl. Phys.*, **26**, *No.* 2, 250 (*Feb.*, 1955).

The ferrite sphere for resonance measurements should be placed away from the walls of the microwave cavity since otherwise there is appreciable correction for field distortion as has been shown by experiment. D. H. WHIFFEN

538.221

4784. Circularly polarized cavities for measurement of tensor permeabilities. E. G. SPENCER, R. C. LECRAW AND F. REGGIA. Letter in *J. appl. Phys.*, **26**, *No.* 3, 354–5 (*March*, 1955).

Since a ferrite resonance splits the degeneracy of a TE cavity, its exact measurement is difficult with linearly polarized exciting radiation, but with right and with left circularly polarized radiation, two distinct curves are obtained and can be analysed separately. D. H. WHIFFEN

538.221

4785. Magnetic structure of manganese arsenide. G. E. BACON AND R. STREET. Letter in *Nature [London]* **175**, 518 (*March* 19, 1955).

A neutron diffraction examination was carried out between 80°K and 130°C. In the ferromagnetic region, from room temperature to 80°K the results suggest that the magnetic moments of the Mn atoms are aligned at right angles to the *c*-axis and not along it. Between the two transformation temperatures of 40° and 130°C no new reflections due to antiferromagnetism, as postulated by Guillaud [Abstr. 6337 (1951)], were observed and it is concluded that any antiferromagnetism must be very weakly developed. J. THEWLIS

538.221

4786. Effect of low temperature on the stability of permanent magnets. A. G. CLEGG. *Brit. J. appl. Phys.*, **6**, *No.* 4, 120–3 (*April*, 1955).

Magnetometer measurements have been made of the change in magnetization with temperature between +60 and −60°C for magnets with a range of dimension ratios. The materials tested were Alcomax III, Columax, Alnico, 35 and 15% cobalt steels. With decreasing temperatures the magnetization increases reversibly except for the shorter dimension ratio magnets in Alcomax III and Columax, for which losses occur. The influence of tempering on these losses is discussed. Losses occur in the lower coercivity materials only with increasing temperature. The losses, whether due to increase or decrease of temperature, can be minimized by a partial demagnetization by an alternating field. The results are correlated with the changes in the demagnetization curves of the materials with temperature. A.

538.221 : 538.632

4787. Spontaneous galvanomagnetism and magnetization of irreversible iron-nickel alloys. A.-L. PERRIER AND E. ASCHER. *C.R. Acad. Sci. [Paris]* **240**, *No.* 10, 1066–8 (*March* 7, 1955) In French.

Results of Hall measurements on an alloy with 30% Ni between 0 and 600°C are analysed as function of the magnetization and the temperature.

E. P. WOHLFARTH

538.221 : 538.65 : 536.413

4788. The Δα effect: [anisotropy of the thermal expansion coefficient of cold-worked ferromagnetic materials]. R. SCHULZE. *Z. angew. Phys.*, **7**, *No.* 2, 57–8 (1955) In German.

Investigations on cold-rolled strips of a commercial

alloy ("Iso-Elastic") containing 36% Ni, 7–8% Cr and 0·5% Mo show that the thermal expansion coefficient is smaller in a direction parallel to the rolling direction than perpendicular to it. The variation of $\Delta\alpha$ with temperature and strain was investigated. A thermodynamical formula for $\Delta\alpha$ is given, relating it to magnetostrictive properties.

E. P. WOHLFARTH

538.221 : 538.652

4789. Temperature relation of the magnetostriction of ferromagnetic alloys. D. I. VOLKOV AND V. I. CHECHERNIKOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 2(8), 208–14 (1954) In Russian.

The temperature relation of the magnetostriction of saturation of ferromagnetic alloys on a nickel base, was investigated in order to establish whether Akulov's linear law relating the constants characterizing the even effect with the temperature (and the saturation magnetostriction at the absolute zero) remained valid for alloys, which seemed doubtful since contradicting results had been obtained by the only two investigators who examined alloys so far. The investigation was carried out on alloys of the systems Ni–Cu, Ni–Mn, Ni–Fe, in a narrow range near the Curie point, and with all the experimental refinements possible. These referred above all to the development of a new and improved type of strain gauges. Within the range investigated, the linear character of the relation was almost perfect and accurately confirmed the validity of Akulov's law. B. F. KRAUS

538.221 : 538.652

4790. The effect of heat-treatment on the longitudinal magnetostriction in weak magnetic fields. S. MATSUMAE. *Kumamoto J. Sci. A*, **1**, *No.* 4, 40–2 (*March*, 1954).

Reports results of measurements on electrolytic nickel in the field range of constant permeability. The magnetostriction is found to be considerably influenced by prior heat treatment which is thought to affect the internal strain of the specimen.

E. P. WOHLFARTH

538.221 : 538.652

4791. Isotropic magnetostriction of small iron samples. K. WOTRUBA. Letter in *Czech. J. Phys.*, **4**, *No.* 3, 372–4 (*Sept.*, 1954) In Russian.

538.221 : 538.66

4792. Relation between the temperature of a ferromagnetic substance and the heat dissipated in its interior by an alternating field. G. RIBAUD AND D. BORDIER. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 7, 703–7 (*Feb.* 14, 1955) In French.

Reports measurements of the heat dissipated at temperatures between room temp. and above the Curie point in cylindrical iron and nickel specimens under the action of an alternating magnetic field of frequency 470 kc/s. The ratio W/i^2 of the dissipated power to the mean square current increases by factors of about 3 for iron and 5 for nickel between room temp. and the Curie point and then drops sharply to low constant values. E. P. WOHLFARTH

538.222

4793. The magnetic susceptibility of metallic neodymium. L. F. BATES, S. J. LEACH, R. G. LOASBY AND K. W. H. STEVENS. Note in *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 3, 181–2 (*March*, 1955).

Reports results on two Nd specimens (0·07% Fe) between 290° and 1 000°K. The room temp. mass susceptibility was found to equal $38{\cdot}6\times10^{-6}$; the susceptibility, temperature curve obeys the Curie–Weiss law up to 500°K ($\theta = -15$°K, $p_B = 3{\cdot}72$), deviations from this law at higher temperatures being interpreted in terms of a temperature dependent electronic excitation process. E. P. WOHLFARTH

538.222

4794. Paramagnetic resonance of methyl substituted *p*-benzosemiquinones. B. VENKATARAMAN AND G. K. FRAENKEL. Letter in *J. chem. Phys.*, **23**, *No.* 3, 588–9 (*March*, 1955).

Interpretation of the hyperfine structure of the electron resonance measured at 3·2 cm leads to the following interaction constants for the H atoms, (*a*) in the ring, and (*b*) in the methyl groups, for derivatives of *p*-benzosemiquinone: Unsubstituted (*a*) 2·33; tetramethyl (*b*) 1·88; 2:5-dimethyl (*a*) 1·80, (*b*) 2·22; 2:6-dimethyl (*a*) 1·88, (*b*) 2·10; monomethyl (*a*) 2·48, 2·48 and 1·73, (*b*) 2·02 gauss where 1 gauss $\equiv$ 2·80 Mc/s. D. H. WHIFFEN

538.222

4795. Measurement of electronic susceptibilities by means of nuclear resonance absorption. G. FEHER AND W. D. KNIGHT. *Rev. sci. Instrum.*, **26**, *No.* 3, 293–4 (*March*, 1955).

The proton nuclear magnetic resonance is observed in two crossed capillary tubes embedded in a paramagnetic material in a constant external field. The resonance frequencies from the two capillaries depend on the respective demagnetizing factors. For Mn_2O_3 the two resonance lines are separated by 13·0 kc/s at 22·3 Mc/s giving a mass susceptibility of 65×10^{-6} c.g.s in agreement with values obtained by other methods. For a magnetic field homogeneity of about one part in 10^7 over the sample, the ultimate sensitivity of the method would be 10^{-7} to 10^{-8} susceptibility unit. Measurements can be made at low temperatures. A.

538.222

4796. Techniques for nuclear magnetic resonance measurements on granular hygroscopic materials. T. M. SHAW AND R. H. ELSKEN. *J. appl. Phys.*, **26**, *No.* 3, 313–17 (*March*, 1955).

An investigation was made of the effects of nonuniformity in the magnetic fields and in the test specimens employed in the measurement of nuclear magnetic resonance absorption. Particular attention was given to the determination of relative integrated line intensity from derivative maxima independently of the uniformity of concentration of the subject nuclei through the available sample volume. The principal objective was to devise techniques applicable to granular hygroscopic materials. A technique applicable for the low-moisture range was tested for materials containing 7 to 16% water and found to be satisfactory. A.

538.222

4797. Paramagnetic resonance absorption by the ferrous ion. M. TINKHAM. Letter in *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 3, 258–9 (*March*, 1955).

Fe^{++} in ZnF_2 shows electron resonance corre-

sponding to the $3d^6$, ^5D ground term with $g_{||} = 8{\cdot}97 \pm 0{\cdot}02$. At 12°K there are signs of hyperfine structure through coupling with the F spins.

D. H. WHIFFEN

538.222 : 539.132

The electronic structure and magnetic properties of uranyl-like ions. Uranyl and neptunyl. *See Abstr.* 4854

538.222 : 541.15

4798. Paramagnetic species in gamma-irradiated ice. M. S. MATHESON AND B. SMALLER. *J. chem. Phys.*, **23**, *No.* 3, 521–8 (*March*, 1955).

The paramagnetic resonance spectra of H_2O and D_2O ice irradiated at 77°K have been examined. The absorbing species have been identified as H and OH (or D and OD), a significant result for the radiation chemistry of aqueous solutions. The yield of radical pairs/100 eV is about 0·14. The hyperfine splittings of the H doublet and D triplet are a factor of 16 less than are observed in the gas phase. This result is attributed to the effect of the solid on the electronic state of the H or D atoms. The spectra of H_2O_2 in H_2O and D_2O_2 in D_2O irradiated at 77°K support the identification of OH (or OD) absorption. In annealing experiments the H and OH disappear near 115°K. Results on solid ammonia and solid formic acid irradiated at 77°K are also described. A.

538.24

4799. The magnetic flux set up by a dipole inside a circular ferromagnetic wire. S. M. RŸTOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 3(9), 307–12 (1954) In Russian.

A general expression is obtained for the flux induced by a magnetic dipole inside an infinite circular ferromagnetic wire. The flux is calculated for a circular area with the centre on the axis of the wire and perpendicular to it. An approximate formula is given for the case that the radii of the wire and area considered are small against the distance of the latter from the dipole. This problem has a special bearing on experiments in which the e.m.f. pulse set up by the remagnetization of a single domain is measured by a ballistic method. Such a single domain may be represented by a magnetic dipole in any case in which the distance of the point considered from the dipole is large compared with the actual dimensions of the domain. The problem of the magnetic dipole may, in turn, reduce to that of a "point charge." The solving expression involves Bessel functions of a complex argument and Macdonald functions, the approximate solution taking a very simple exponential form. B. F. KRAUS

538.24

4800. Experimental investigation of the variation of the magnetic flux in a wire when a single domain is remagnetized. A. A. GRACHEV, K. A. GORONINA, N. N. KOLACHEVSKIĬ AND I. A. ANDRIANOVA. *Zh. éksper. teor. Fiz.*, **27**, *No.* 3(9) 313–17 (1954) In Russian.

The remagnetization of a ferromagnetic specimen by a periodic field sets up an e.m.f. in the indicator coil wound round the specimen, the spectrum of which has line and continuous character, the latter due to the irreversibility of the remagnetization e.m.f. This fraction of it may be called the noise voltage. The noises of a cyclic remagnetization in two sections of a wire are partly correlated. This correlation is actually of two different kinds which may be separated by two indicator coils placed near enough to each other on the specimen, and may be distinguished as flux and domain correlation. In a specially treated carbon steel wire it was possible to select a section which contained a large domain (volume about 10^{-5} cm^3) and many small ones (10^{-9} cm^3). The section containing this large domain was covered by a magnetizing coil of 2 mm length, so that remagnetization affected only this single large domain. An analysis of the effects of remagnetization obtained with a moving and a series-connected fixed indicator coil feeding into separate c.r.o.'s enabled the flux variations due to the remagnetization of the large domain to be separated from those of the small domains. The distribution of the field of the domain along the wire coincided within 10% with RŸTOV's theoretical curve obtained on the assumption of a dipole character of the magnetic domains.

B. F. KRAUS

538.24

4801. The fundamental magnetization processes in Alnico permanent magnet alloys. H. FAHLENBRACH. Note in *Naturwissenschaften*, **42**, *No.* 3, 64–5 (1955) In German.

Gives brief results of electron-microscopical investigations of the precipitation process in magnetically annealed Alnico alloys at various stages of the heat treatment, including that giving optimum permanent magnet properties [energy product $(BH)_{max} = 5 \times 10^6$]. Qualitative estimates are also made of the saturation magnetizations and Curie temperatures of the precipitates and the matrix. [For a full account see *Technische Mitteilungen Krupp*, **12**, 177 (1954).]

E. P. WOHLFARTH

538.24

4802. Torsion method measurements of the magnetization curves of thin ferromagnetic films. J. BROŽ AND J. ŠTERNBERK. Letter in *Czech. J. Phys.*, **5**, *No.* 1, 96–8 (*Feb.*, 1955) In Russian.

538.24

4803. Barkhausen noise from a cylindrical core. D. HANEMAN. Letter in *J. appl. Phys.*, **26**, *No.* 3, 355–6 (*March*, 1955).

Derives an expression for the Barkhausen noise in a ferromagnetic core under the action of a saw-tooth exciting field; this allows the application of Campbell's theorem. The expression is applied to part of the range of a sine-wave exciting field, and it is shown that the maximum noise in a frequency range Δf is proportional to f. E. P. WOHLFARTH

538.24 : 538.653.1

4804. An elastomagnetic effect. G. O. GALE. *Proc. Iowa Acad. Sci.*, **61**, 330–3 (1954).

Reports measurements on iron and nickel wires surrounded by a solenoid. The sudden application or removal of tension to the wire causes voltages of the order 10μV to be induced in the coil, these voltages being believed to be due to Barkhausen

discontinuities. The effect can be reversed by application of a direct current [see also Abstr. 4500 (1952)].

E. P. WOHLFARTH

538.27

4805. The de Haas–van Alphen effect. III. Experiments at fields up to 32 kG. J. S. DHILLON AND D. SHOENBERG. *Phil. Trans A*, **248**, *No.* 937, 1–21 (1955).

For Pt II, see Abstr. 5913 (1952). The periodic field-dependence of magnetic anisotropy (de Haas–van Alphen effect) has been studied for bismuth and zinc crystals by the torque method between about 1·5 and 32 kG at 4·19°K and about 1·5°K; in each case the orientation was chosen so that only a single fundamental periodicity was present. Particular attention was paid to the phase and harmonic content of the oscillations and to the form of the field-dependence of amplitude. For bismuth good agreement was found with the theoretical formula except that the signs of the fundamental and the odd harmonics had to be reversed. For zinc the field-dependence of amplitude at high fields was quite at variance with the theoretical formula and (probably in consequence) the harmonics were much weaker than in bismuth; the phases of the fundamental and the first harmonic were quite different from those of the theoretical formula. A slight field-dependence was found for bismuth even at 85°K, similar to the rather more marked one previously found in zinc. Oscillations of very much shorter period than the main ones were observed in zinc at the highest fields and their characteristics were briefly studied. Qualitative observations were made of the very short-period oscillations in a lead crystal, previously only observed by an impulsive method at much higher fields. No oscillations could be detected in copper, silver or gold crystals. A.

538.27

4806. On the question of the effect of stresses produced during precipitation. F. VICENA. *Czech. J. Phys.*, **5**, *No.* 1, 11–17 (*Feb.*, 1955) In Russian.

It is assumed that various physical processes such as age hardening, work hardening or the presence of dislocations will affect the existence of internal stresses of various types in a ferromagnetic and that their influence on the coercive force will therefore differ. The effect of internal stress produced in the process of precipitation in the vicinity of particles of the precipitated phase on the coercive force of the ferromagnetic is investigated. The following assumptions are made: the form of the precipitated particle is regarded as isotropic (spherical), the Bloch wall is considered plane and the distance between the precipitates is considered large in comparison with their size. The character of the tension in the surroundings of the spherical precipitate was investigated by Mott and Nabarro (1940). Their explanation of the tensor of tension in the surroundings of the precipitates was taken as a basis for the present calculations. Particular attention was paid to the influence of the effect of surface tension of the Bloch wall and the effect of magnetic charges. It is shown that with spherical particles the first influence need not be considered at all, due to the symmetry existing, and that the second can be neglected in comparison with the effect of magnetic charges produced on the surface of a particle of the precipitate on the direction of spontaneous magnetization. The conclusion is drawn that with precipitates of spherical shape (e.g. carbide of iron, Fe_3C, in iron) the internal stresses produced by them in their vicinity during precipitation do not in any marked degree influence the movement of the Bloch wall across these inclusions and thus also the coercive force. Thus the opinion held by some authors that the internal stresses influencing the coercive force (which is the subject of the "stress theory") were produced in the vicinity of the precipitates during age hardening, is not justified. A.

ELECTROMAGNETISM . ELECTRODYNAMICS 538.3/.5

538.3

4807. General considerations on the propagation of electromagnetic waves in moving bodies. G. LAMPARIELLO. *R.C. Accad. Naz. Lincei*, **17**, *No.* 1–2, 37–44 (*July–Aug.*, 1954) In Italian.

538.3

4808. A rigorous solution of Minkowski's equations in the electrodynamics of moving bodies and its physical interpretation. G. LAMPARIELLO. *R.C. Accad. Naz. Lincei*, **17**, *No.* 3–4, 100–8 (*Sept.–Oct.*, 1954) In Italian.

538.3 : 530.12

4809. The general equation for electromagnetic waves in moving bodies. G. LAMPARIELLO. *R.C. Accad. Naz. Lincei*, **17**, *No.* 5, 222–8 (*Nov.*, 1954) In Italian.

A uniform medium (reference system S') moves with constant velocity parallel to the (x, y) plane of reference system S. The wave equation $(\epsilon\mu/c^2)(\partial^2/\partial t'^2)\Phi' = \nabla'^2\Phi'$ is assumed in S' and the transformed equation in S is discussed. R. A. NEWING

538.3 : 530.145

The use of real spinors for the description of the electromagnetic field. *See Abstr.* 4364

538.3 : 536.7 : 530.12

The field equations for an electromagnetic fluid-field system. *See Abstr.* 4345

538.52

4810. Induction due to thermal fluctuations of a magnetic field. G. KLANKE. Note in *Naturwissenschaften*, **42**, *No.* 4, 92 (1955) In German.

A magnetic circuit is envisaged to consist of three components, one a permanent magnet material, one a high-permeability material and one a material with relatively low Curie temperature. By rapid heating and cooling of the latter between room temp. and its Curie point, an effective air gap is created and destroyed in the circuit and thus a "thermoelectric voltage" induced in a coil surrounding the circuit.

E. P. WOHLFARTH

538.52 : 621.318.42

4811. The noise generated in a coil with a ferromagnetic core. G. BUILDER AND D. HANEMAN. *Austral. J. Phys.*, **7**, *No.* 4, 654–8 (*Dec.*, 1954).

Discusses whether Nyquist's formula $E_f^2 df = 4kTR_f df$ for the noise generated by thermal fluctua-

tions and eddy currents in a cored coil is valid if the ferromagnetism of the core contributes to the noise through the Barkhausen effect. E. P. WOHLFARTH

ELECTROMAGNETIC WAVES AND OSCILLATORS 538.56

538.561 : 523.72

Effect of magnetic fields on generation of noise by isotropic turbulence. *See Abstr.* 4295

538.566

4812. The interaction between an obliquely incident plane electromagnetic wave and an electron beam. I. H. WILHELMSSON. *Chalmers Tekn. Högsk. Handl.*, *No.* 155, 30 *pp.* (1954).

Presents a detailed analysis for the case of a circular beam, of infinite length, surrounded by a dielectric medium. Small signal conditions are assumed. In general both TE and TM scattered waves are required both inside and outside the beam, in order to satisfy the boundary conditions at the interface. The calculations are carried out for two different polarizations of the incident wave, from which the case of arbitrary polarization may be derived by superposition. General expressions for the amplitude of the scattered waves are obtained. The angular variation of the amplitude of the total resultant scattered field is shown for some special cases; when the axial velocity of the incident wave equals the beam velocity, the scattering is identical with that produced by a metallic rod. A particular case is examined in some detail, and numerical results are presented. The solution is extended to include relativity effects. E. A. ASH

538.566

4813. Reflection of a transient electromagnetic wave at a conducting surface. J. R. WAIT AND C. FROESE. *J. geophys. Res.*, **60**, *No.* 1, 97–103 (*March*, 1955).

A solution is given for the reflection of a transient electromagnetic plane wave at oblique incidence from the plane interface of a dissipative medium. The inversion of the Laplace transforms can only be carried out in closed form in special cases. Series solutions are developed for the general case and the numerical results are presented in graphical form. Brief mention is made of the possible application of this solution to the reflection of a radio atmospheric at a sharply bounded ionosphere. A.

538.566

4814. Bistatic radar cross sections of surfaces of revolution. K. M. SIEGEL, H. A. ALPERIN, R. R. BONKOWSKI, J. W. CRISPIN, A. L. MAFFETT, C. E. SCHENSTED AND I. V. SCHENSTED. *J. appl. Phys.*, **26**, *No.* 3, 297–305 (*March*, 1955).

The results obtained by applying the current-distribution method to the problem of approximating the scattering cross-section, when the transmitter and receiver are separated, are presented for several simple geometric configurations. The method is applied for the case in which the transmitter is located on the axis of revolution and the ratio l/λ is large, where l is a "characteristic dimension" of the body and λ is the wavelength. These results indicate that in most of the cases considered the cross-section increases as the angle between the receiver and the transmitter increases. A.

538.566 : 534.26

4815. Electromagnetic and acoustic scattering by a semi-infinite body of revolution. C. E. SCHENSTED. *J. appl. Phys.*, **26**, *No.* 3, 306–8 (*March*, 1955).

The first two terms of Kline's asymptotic expansion are obtained for the scattering of a plane wave incident along the axis of a perfectly reflecting semi-infinite body of revolution. When this method is applied to the paraboloid the exact electromagnetic solution is obtained in closed form. The accuracy of the method of physical optics is studied by using the asymptotic expansion. A.

538.566 : 534.26

4816. Electromagnetic and acoustical scattering from a semi-infinite cone. K. M. SIEGEL, J. W. CRISPIN AND C. E. SCHENSTED. *J. appl. Phys.*, **26**, *No.* 3, 309–13 (*March*, 1955).

The value of the nose-on back-scattering cross-section of a semi-infinite cone is determined by the exact methods of electromagnetic and acoustical theory, and by physical optics. It is shown that, to the degree of approximation used, the electromagnetic value and the physical-optics value are equal. The acoustical value is found to be less than the electromagnetic value by a factor which depends only on the cone angle; both are proportional to the square of the wavelength. It is shown that the electromagnetic and physical-optics answers agree with experimental data to within a factor of two. The electromagnetic theory results obtained hold for the cases in which the half-cone angle is close either to 0 or to $\pi/2$. A.

538.566 : 535.43 : 534.26

The scattering of a scalar wave by a semi-infinite rod of circular cross section. *See Abstr.* 4464

538.566 : 621.318.12/.13

4817. On the microwave Cotton–Mouton effect in Ferroxcube. F. K. DU PRÉ. *Philips Res. Rep.*, **10**, *No.* 1, 1–10 (*Feb.*, 1955).

The ordinary beam has its magnetic field parallel to H, the extraordinary beam perpendicular to H. The beams will emerge with a phase difference. This phase difference is determined for Ferroxcube 4B as a function of the field. The frequency used is 9350 Mc/s. By application of Polder's theory to the simplified case of plane-wave transmission through a ferrite having a small damping loss, fair agreement with the experimental results is obtained. A.

538.566

4818. On the possibility of electromagnetic surface waves. P. S. EPSTEIN. *Proc. Nat. Acad. Sci. U.S.A.*, **40**, *No.* 12, 1158–65 (*Dec.*, 1954).

Discusses the types of wave capable of propagating along the plane of discontinuity of two different media. A plane wave incident on the boundary sets up a wave travelling parallel to it in the second medium. It is found that in no case of practical interest can a wave be set up which propagates parallel to the surface in both media simultaneously. G. D. SIMS

538.566

4819. Transformation of Sommerfeld's formula for vertical dipole. I. Šantavý. Letter in *Czech. J. Phys.*, **4**, *No.* 4, 508–9 (*Nov.*, 1954) In Russian.

It is shown that the relation previously obtained [H. Weyl, *Ann. Phys.* [*Leipzig*] **60**, *No.* 5, 481–500 (*Nov.* 20, 1919)] for the space-wave can be deduced directly from Sommerfeld's formula for the potential function of an electric dipole, situated at a plane boundary of two semispaces, with its axis perpendicular to the boundary. Z. F. WOJNAR

538.566

4820. Multipoles and Schelkunoff waves. I. Ferrari. *R.C. Accad. Naz. Lincei*, **17**, *No.* 1–2, 32–7 (*July–Aug.*, 1954) In Italian.

It is shown that the field of the multipole of order n is a linear combination of Schelkunoff waves up to the order n. Only waves of even (odd) number appear in the expansion for n even (odd). A method is indicated for the determination of the coefficients, whose explicit expression is given for $n = 1, 2, 3$. In particular, apart from a multiplying constant, the second Schelkunoff wave represents the field of a quadrupole. L. PINCHERLE

538.566.2

4821. On a refinement of the theory of the propagation of long electric waves round the earth. J. Weidner. *Z. angew. Phys.*, **7**, *No.* 2, 77–82 (1955) In German.

Considers a second term in the theory of Schumann [Abstr. 6155 (1952)]. This is shown to be negligible for wavelengths greater than 180 km and inadequate for wavelengths less than 40 km. J. M. HOUGH

538.566.3

4822. Theory of coupling of ordinary and extraordinary electromagnetic waves in an inhomogeneous and anisotropic plasma and the conditions of reflection. Applications to the ionosphere. R. Jancel and T. Kahan. *J. Phys. Radium*, **16**, *No.* 2, 136–45 (*Feb.*, 1955) In French.

The authors' theory of feebly ionized plasmas in the presence of varying electric and constant magnetic fields is summarized and applied to propagation studies of e.m. waves in an inhomogeneous layer and the o- and x-wave coupling. Using the method of the B.K.W. approximations the refractive indices of such a layer are defined and the conditions of reflection corresponding to different modes of propagation deduced. G. M. BROWN

MOLECULAR AND ATOMIC STRUCTURE 539.1

THEORY OF SOLID STATE 539.11

539.11

4823. Zero-point energy of monatomic crystals. W. C. DeMarcus. Letter in *J. chem. Phys.*, **23**, *No.* 3, 602 (*March*, 1955).

Shows that the total lattice energy of a crystal may be expressed as the sum of the energies of the individual atoms with all other atoms being in their equilibrium positions; an analogy is established with the many-electron problem treated on the basis of Hartree's approximation. The zero-point energy is proportional to the first moment of the frequency spectrum, and this is shown to be given by $\bar{\nu} = (15\overline{\nu^2})^{\frac{1}{2}}/4$. E. P. WOHLFARTH

539.11

4824. Vibrational anharmonicity and lattice thermal properties. II. D. K. C. MacDonald and S. K. Roy. *Phys. Rev.*, **97**, *No.* 3, 673–6 (*Feb.* 1, 1955).

For previous part, see Abstr. 11255 (1954). The analysis of the thermal properties of a linear chain is now extended to cover an interatomic potential of arbitrary form. The Lennard-Jones potential is taken as an example and the results for the thermal expansion coefficient are compared with experimental data. A.

539.11 : 530.162

Relations between canonical and microcanonical ensembles. *See Abstr.* 4392

539.11 : 539.13 : 548.7

4825. On the theory of transitions in molecular crystals. L. Jansen and F. W. de Wette. Letter in *Physica*, **21**, *No.* 1, 83–4 (*Jan.*, 1955).

Discussion of contributions to molecular interaction potentials affecting transitions in N_2 and CO from f.c.c. to h.c.p. lattices, and similar transitions in O_2. Experimental trends confirm the importance of quadrupole moments and anisotropy of London dispersion forces. See also Abstr. 7854 (1954), 2920–2 (1955). J. HAWGOOD

539.11

4826. The mechanism of the irradiation disordering of alloys. G. H. Kinchin and R. S. Pease. *J. nuclear Energy*, **1**, *No.* 3, 200–2 (*Feb.*, 1955).

An atom moving through a crystal as a result of a heavy-particle collision may change places with a stationary atom. Calculations of the numbers of such replacements suggest that this mechanism may be responsible for the rapid disordering produced in ordered alloys by irradiation. A.

539.11

4827. Disordering of solids by neutron radiation. W. S. Snyder and J. Neufeld. *Phys. Rev.*, **97**, *No.* 6, 1636–46 (*March* 15, 1955).

A general method is outlined for determining the number of vacant lattice sites or interstitial atoms in a monatomic solid exposed to neutron radiation. The colliding atoms are assumed to be within the energy range for which the orbital picture can be applied. Following the treatment of Bohr, the scattering regions of excessive and moderate screening, Rutherford distribution, and electronic collisions are considered separately. The number of vacancies or interstitial atoms as a function of the energy of the primary knocked-out atoms is given by the solution of certain integral equations that are different for various energy regions considered. It is found that if the velocity of a recoil atom resulting from neutron collision is less than $e^2/\hbar$ (region of elastic collisions) approximately half of its energy is used to produce vacancies or interstitials. If the velocity of the recoil atom is above

$e^2/\hbar$ (region of inelastic collisions) then the energy used to produce vacancies and interstitials is approximately constant for medium and heavy elements. A simple formula has been derived expressing the average number of vacant lattice sites or interstitials produced in a collision of a neutron having energy E in a monatomic solid composed of medium or heavy elements having atomic mass M. The formula is as follows: $G(E) \sim (nE - \alpha)^2/4\alpha nE$, for $E \leqslant \gamma/n$; $G(E) \sim [(nE - \alpha)^2 - (1 - \bar{R})(nE - \alpha - \gamma)^2]/4\alpha nE$, for $E \geqslant \gamma/n$, where $\gamma = Me^4/2\hbar^2$; $n = 4M/(M + 1)^2$, α is the binding energy of an atom in the lattice, and $\bar{R}$ is a slowly varying function of Z. A.

539.11

4828. Ordering processes in Cu_3Au. F. P. BURNS AND S. L. QUIMBY. *Phys. Rev.*, **97**, *No.* 6, 1567–75 (*March* 15, 1955).

Data are reported which describe the isothermal time rate of change of electrical resistivity in a specimen of Cu_3Au following a quench from a temperature above the critical temperature (393°C) to one below it. The experimental arrangements permit observation within one minute after the initiation of the quench. At quench temperatures above 364°C the resistivity rises and then decreases, at first rapidly and then more slowly. The initial rate of fall increases as the quench temperature is lowered. Below 364°C the early rise is absent and the rate of fall decreases with decreasing temperature. The several phenomena are consistent with the hypothesis that the processes involved are the formation, by statistical fluctuation, of stable antiphase nuclei of order in the disordered matrix, the growth of these nuclei, and the coalescence of the resultant antiphase domains. An approximate quantitative theory is developed. Measurements of the isothermal time rate of change of resistivity in an annealed specimen following sudden change of temperature below the critical temperature are in accord with the kinetic theory recently proposed by Jerome Rothstein. A.

539.11

4829. On the question of the type of binding in carbides of transition metals. H. RENNER, G. BRAUER AND A. FAESSLER. Note in *Z. Naturforsch.*, **10a**, *No.* 2, 171–2 (*Feb.*, 1955) In German.

The broadening and line shape of the $L\beta_2$ emission line of the X-ray spectrum of the carbides NbC and Nb_2C were compared with Nb metal and Nb_2O_5. It is found that the higher carbide is more similar to the oxide, and the lower to the metal, and this is interpreted as implying tighter binding in the former.

W. M. LOMER

539.11

4830. Nuclear spin exchange in solids: Tl^{203} and Tl^{205} magnetic resonance in thallium and thallic oxide. N. BLOEMBERGEN AND T. L. ROWLAND. *Phys. Rev.*, **97**, *No.* 6, 1679–98 (*March* 15, 1955).

The line width of the Tl^{203} and Tl^{205} nuclear magnetic resonance in thallium and thallium oxide greatly exceeds the dipolar width, and is a function of the abundance of the other isotope. The results can be interpreted in terms of an exchange interaction AI_1I_2 between a pair of nuclear spins which exceeds the normal dipolar interaction. The exchange between different isotopes leads to broadening. Exchange between like nuclei should lead to narrowing, but it was found that samples containing 98·7% Tl^{205} still exhibit lines broader than the dipolar interaction. Two causes are shown to exist: anisotropy of the chemical shift and pseudo-dipolar exchange interaction. Analysis with the method of the moments gives for the exchange interaction constant $Ah^{-1} = 17{\cdot}5$ kc/s with a 30% anisotropic pseudo-dipolar character in the hexagonal metal, and $Ah^{-1} = 12$ kc/s with less than 10% pseudo-dipolar character in thallic oxide. The oxide has a chemical shift of +0·55% with an anisotropy of 34% of this amount. The metal exhibits a shift of 1·56% with 16% anisotropy. Ramsey's theory of the nuclear spin exchange via excited electron states in molecules, is extended to solids. Most heavy isotopes in metals and insulators should exhibit exchange effects. From the anisotropy of the exchange, information about the relative amount of p or d character of the electron wavefunction in the solid can be obtained. It is predicted that thallic oxide has a nuclear Curie point at $3{\cdot}5 \times 10^{-6}$°K. Whether it will become nuclear ferromagnetic or antiferromagnetic depends on details of the electronic band structure. A.

539.11

4831. Electronic density of states of graphite. J. E. HOVE. Letter in *Phys. Rev.*, **97**, *No.* 6, 1717–18 (*March* 15, 1955).

Next nearest neighbour interactions give rise to a discontinuity in the electronic density of states at the junction of filled and empty band. This is of the same form as found previously [Abstr. 4767 (1954)] from consideration of the asymmetry of surroundings for two pairs of atoms in the unit cell. F. ANSBACHER

MOLECULES 539.13

539.13 : 548.736.1

4832. On intermolecular forces and the crystal structures of the rare gases. J. JANSEN AND L. M. DAWSON. *J. chem. Phys.*, **23**, *No.* 3, 482–6 (*March*, 1955).

The relation between the intermolecular potential field and the stability of crystal structures of the rare gases is investigated for a face-centred cubic lattice and a structure of hexagonal closest packing. Two models of the potential field are used: a Lennard-Jones (s, 6) potential and a "modified" Buckingham potential (α, 6). The effect of zero-point energy is taken into account on the basis of Corner's method. It is found that for an additive Lennard-Jones (s, 6) potential (s between 7 and 16) the hexagonal structure is the stable one. For an additive Buckingham potential (α, 6), with α varying from 10 to 16, the hexagonal lattice is again more stable than the cubic structure. For both forms of the potential field considered in the analysis, the differences in energy between the two structures is of the order of one tenthousandth of the cohesive energies of the crystals. These results agree with the conclusions reached by Kihara and Koba, who neglected the influence of

zero-point energy. It is known from experiments that neon, argon, krypton and xenon crystallize in the face-centred cubic lattice. Therefore, if additivity of intermolecular forces is assumed, the results indicate that neither the Lennard-Jones nor a modified Buckingham potential can explain the crystal structures of the rare gases except helium. The possible importance of many-body interactions is discussed. A.

539.132

4833. Studies on the hydrogen bond. I. Potential function of the hydrogen bond. K. KAKU. *Kumamoto J. Sci. A*, **1**, *No.* 4, 55–9 (*March*, 1954).

To construct a potential function for O–H . . . O with 2 minima, Morse functions for O–H and H . . . O with the same parameters are superposed. Hence the O–H distance, force constant and height of the potential barrier are determined in fair agreement with experimental values. J. JACOBS

539.132

4834. The problem of internal rotations of molecules. TANG AU-CHIN. *Scientia Sinica*, **3**, *No.* 3, 279–99 (*Sept.*, 1954).

Theoretical discussion of electrostatic interactions leads to the potential function for internal rotation $V(\phi) = \sum_{i,j} \sum_{m=0}^{\infty} A_{ijm} \cos m\phi$ where A_{ijm} is a constant depending on the charge distributions in bonds i and j and ϕ is the rotation angle. For practical use, this series is cut off at $m = 3$, and the A's treated as empirical quantities, transferable from molecule to molecule. There is a careful discussion of the interrelations of the potentials for molecules within certain groups, e.g. halogenated ethanes, methylated butanes. Internal rotations of ethanol, H_2O_2, NH_2 and $(CXYZ)_2$ are also treated. Results agree well with experiment. The terms in $\cos 2\phi$, usually neglected, are important in many cases with threefold symmetry. J. HAWGOOD

539.132

4835. Calculation of the potential energy constants of COF_2, $COCl_2$ and COFCl. J. MALÝ AND L. KUČA. *Czech. J. Phys.*, **5**, *No.* 1, 30–9 (*Feb.*, 1955) In Russian.

The set of constants of the general quadratic potential functions of COF_2, $COCl_2$ and COFCl are calculated from the infrared and Raman spectra of these molecules as given in the literature. Since the number of unknown potential constants is greater than the number of basic frequencies of this set of molecules, certain constants [$K(q_X)$, $K(q_Xq_Y)$ and $K(q_Xq'_{XY})$, where X, Y = halogen] were taken from halogenmethane and for certain small interaction constants limiting assumptions were made. The calculation is carried out according to the method of normal co-ordinates according to Stěpanov with matrices of potential and kinematic constants containing all non-diagonal members. The value of $K(q_0)$ for COF_2 is $24{\cdot}3\times10^6\,cm^{-2}$, for COFCl $23{\cdot}3\times10^6\,cm^{-2}$ and for $COCl_2$ $22{\cdot}3\times10^6\,cm^{-2}$. The maximum absolute deviation of frequency calculated from this set of constants from the measured values is $33\,cm^{-1}$, the mean absolute deviation is $8\,cm^{-1}$. The error in solving the secular equations by the method of successive diagonalization is $\pm20\,cm^{-1}$. The calculation verified the correctness of the empiric choice of the basic frequencies and their co-ordination with symmetry types, as performed by Nielsen in the work from which the vibration frequencies were taken A.

539.132

4836. Influence of vibration-rotation interaction on line intensities in vibration-rotation bands of a rotating Morse oscillator. R. HERMAN AND R. J. RUBIN. *Astrophys. J.*, **121**, *No.* 2, 533–40 (*March*, 1955).

The effect of vibration-rotation interaction on line intensities in vibration-rotation bands of diatomic molecules is investigated for a diatomic molecule treated as a rotating Morse oscillator with fixed electronic angular momentum. The matrix element of the electric dipole moment is calculated for the transition $v, J, \lambda \rightarrow v', J', \lambda$, using Morse–Pekeris wave-functions, where the electric dipole moment is written as a Taylor series expansion about the equilibrium internuclear separation. The matrix element of the nth-order term in the dipole-moment expansion can be simply derived from the matrix element of the zeroth-order term. The matrix elements of the first four terms are given explicitly. These results greatly extend those of the perturbed harmonic oscillator treatment of Herman and Wallis, since they apply to all v, v' to within the accuracy of the expansion of the rotational energy. The matrix elements obtained when $J \rightarrow 0$ and $\lambda \rightarrow 0$ generalize the results obtained by Heaps and Herzberg, since they include all the terms in the electric dipole-moment expansion. A.

539.132

4837. Normal coordinate treatment of dimethyldiacetylene. A. WEBER AND S. M. FERIGLE. *J. chem. Phys.*, **23**, *No.* 3, 579–82 (*March*, 1955).

A normal co-ordinate treatment for dimethyldiacetylene is carried out, using Wilson's **FG**-matrix method in conjunction with the "splitting out" technique. All the potential constants have been transferred from similar molecules and the agreement between calculated and observed frequencies is good, the largest deviation being 2·3%. The observed fundamentals are a_1—2914, 2264, 1381, 1228 and 554 K; $\bar{a}_2$—2947, 2163, 1379 and 941 K; e—2947, 1458, 1030, 353 and 104 (calculated) K; and $\bar{e}$—2953, 1426, 1022, 475 and 247 K. A.

539.132 : 535.343

4838. Molecular structure and vibrational spectra of ethyl cyanide. N. E. DUNCAN AND G. J. JANZ. *J. chem. Phys.*, **23**, *No.* 3, 434–40 (*March*, 1955).

The infrared spectra for the gaseous and liquid states, and the Raman spectra for the liquid state, including intensity and polarization data, are reported. A normal co-ordinate treatment has been made for four planar and five non-planar skeletal vibrational modes. The observed spectra are in accord with a C_s model for this molecule. A complete assignment of frequencies to the fundamental modes of vibration is made for ethyl cyanide. From the spectroscopic data, the height of the barrier hindering internal rotation is estimated to be 5200 cal. The thermodynamic functions for ethyl cyanide have been calculated to 1000°K. A.

539.132 : 539.133

4839. Correlations between characteristic frequencies of the paraffins and the skeletal frequencies of some structurally analogous polar molecules. N. SHEPPARD AND D. M. SIMPSON [MRS. J. N. AGAR]. *J. chem. Phys.*, **23**, *No.* 3, 582–4 (*March*, 1955).

Some close analogies are found in the region 1 500 to 600 cm^{-1} between the frequencies of a number of paraffins and their more polar analogues in which CH_3 groups are replaced by F, OH, or NH_2 groups. The great intensities of the infrared bands of the polar molecules have led to their assignment to skeletal stretching modes; a similar assignment for the frequencies of the paraffins may therefore be deduced. On this criterion the 1 053 cm^{-1} band of propane, the 1 170 cm^{-1} band of isobutane and the 1 249 cm^{-1} band of neopentane are to be attributed principally to skeletal stretching vibrations. Some apparently contradictory conclusions reached earlier from studies of deuterium-substituted propanes and neopentanes are discussed. A.

539.132

4840. Rotational excitation by slow electrons. E. GERJUOY AND S. STEIN. *Phys. Rev.*, **97**, *No.* 6, 1671–9 (*March* 15, 1955).

Cross-sections are calculated for rotational excitation of a homonuclear diatomic molecule by collisions with very slow electrons. The mechanism is assumed to be the long-range quadrupole interaction. The Born approximation is shown to be correct in the low-energy limit. The results are applied to calculation of energy losses in N_2, and comparison is made with values inferred from swarm and cross-modulation experiments. At energies below 0·29 eV, the threshold for vibrational excitation, losses are approximately twice the experimental values, but many times larger than the value $(2m/M)$ for elastic losses only. A.

539.132 : 535.343

4841. The electronic spectra of aromatic molecules. III. The effect of inductive substituents. J. N. MURRELL AND H. C. LONGUET-HIGGINS. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 329–39 (*April*, 1955).

For Pt II, see Abstr. 2971 (1955). The theoretical interpretation of aromatic hydrocarbon spectra in Pt I [Abstr. 11307 (1954)] is used as a basis for interpreting the effects of inductive substituents on the spectra of these molecules. It is shown that of the four main bands in the hydrocarbon spectrum, the α-band of Clar is the most sensitive to substitution, and relations are derived between the intensity increase and the wavelength shift in the observed bands for various positions of substitution in benzene. The theoretical results are shown to be in reasonable agreement with available data on the fluorobenzenes. A.

539.132

4842. Study of nuclear resonance of the supercooled rotational transition of 2,3-dimethylbutane. H. SEGALL AND J. G. ASTON. *J. chem. Phys.*, **23**, *No.* 3, 528–31 (*March*, 1955).

The proton magnetic resonance lines during the transition of the supercooled variety of 2,3-dimethylbutane to the normal state have been investigated. An increase in rotational characteristics is followed by an exponential decrease in peak height of the resonance line. This is interpreted in terms of a transition around Frenkel holes. An observed asymmetry in the line shape is treated mathematically on this basis. A.

539.132

4843. Magnetic shielding of nuclei in molecules by a variational method. J. F. HORNIG AND J. O. HIRSCHFELDER. *J. chem. Phys.*, **23**, *No.* 3, 474–6 (*March*, 1955).

The accurate measurement of nuclear magnetic moments requires a calculation of the magnetic field at the nucleus arising from the orbital motions of the electrons in the external magnetic field. In this note a solution of the "magnetic shielding effect" is outlined, using the quantum-mechanical variation principle. Since all results are in terms of ground-state wave-functions, such an approach may facilitate a purely theoretical evaluation of shielding constants. As a variation function a function of the type suggested by Hylleraas and Hassé is taken and applied successfully to calculation of polarizabilities. Previously, Ramsey used a second-order perturbation method to calculate the magnetic shielding. His results are difficult to apply since the wave-functions of excited electronic states of molecules are seldom available. A.

539.132

4844. Free magnetic induction in nuclear quadrupole resonance. M. BLOOM, E. L. HAHN AND B. HERZOG. *Phys. Rev.*, **97**, *No.* 6, 1699–709 (*March* 15, 1955).

The free precession of an ensemble of nuclear quadrupole moments in an axial electric field gradient is studied by the pulsed nuclear induction method. A quantum mechanical analysis describes the free precession and spin echo signals which result from the application of single and double pulses of radio-frequency field at the condition of zero-field quadrupole resonance. Beat modulation effects exhibited by free precession signals in a small constant external magnetic field are predicted by analysis. An alternative semiclassical description of quadrupole precession is given, which is analogous to the macroscopic nuclear induction equations of Bloch. Theory is verified by observation of free precession signals of chlorine in $NaClO_3$. A.

539.132

4845. Determination of the ionic character with the aid of the theory of stability ratios. G. N. SCHRAUZER. Note in *Naturwissenschaften*, **42**, *No.* 2, 43 (1955) In German.

The new formulation of electronegativity due to Sanderson helps to determine the ionic character and dipole moment of a bond, the only postulate being exchange of electronegativity on bond formation. A comparison with experiment for about 30 bonds gives good agreement, including both polar and covalent cases. J. JACOBS

539.132

4846. A relation between the overlap integral and some empirical values of the participating atoms. H. PREUSS. *Z. Naturforsch.*, **10a**, *No.* 1, 52–4 (*Jan.*, 1955) In German.

The overlap integral is related to the ionization energies and electron affinities of the atoms *a*, *b* as well as to bound-energies *a–a*, *b–b*. A semi-empirical interpretation of this relation is given. J. JACOBS

539.132

4847. Structures of the halogen molecules and the strength of single bonds. R. S. MULLIKEN. *J. Amer. Chem. Soc.*, 77, *No.* 4, 884–7 (*Feb.* 20, 1955).

The relatively low bond energy of F_2 can reasonably be understood in terms of an accumulation of non-bonded repulsions, and the higher values for the heavier halogens in terms of *d* hybridization. The latter should impart pronounced multiple-bond character to the "single" bond in Cl_2, Br_2 and I_2. Analogous considerations apply to other first-row and higher-row atom conventional single bonds, and give a reasonable explanation of the relatively greater tendency of first-row than of higher-row atoms to form conventional multiple bonds. In connection with the discussion of Cl_2, it is shown how the use of "unnaturally" small *d* orbitals can be legitimate and important in *p–d* hybridization. A.

539.132

4848. Electron interaction in hydrocarbon multiple ions. N. S. HUSH AND J. BLACKLEDGE. *J. chem. Phys.*, **23**, *No.* 3, 514–17 (*March*, 1955).

The relative ground-state electronic energies of singly and doubly-charged negative ions of unsaturated hydrocarbons are discussed in terms of systematically-approximated self-consistent molecular orbital theory. It is concluded that in the gas-phase and in solution, R^- ions will be stable by several eV to disproportionation into *R* and $R^=$, which accords well with the recent paramagnetic resonance measurements of Lipkin *et al.* Further implications relevant to the solution chemistry of these ions are briefly discussed. A.

539.132

4849. An SCF LCAO MO study of N_2. C. W. SCHERR. *J. chem. Phys.*, **23**, *No.* 3, 569–78 (*March*, 1955).

The self-consistent-field molecular-orbital method in the LCAO (linear combination of atomic orbitals) approximation is applied to the ground-state configuration of the nitrogen molecule at the observed equilibrium internuclear separation. No other approximations are used; all electrons are included. The forms of the resulting molecular orbitals are discussed. The *s–p* hybridization is computed to be 26·1% in agreement with Mulliken's magic formula estimation of 21%. The quadrupole moment is computed to be −1·87 a.u. (experiment, 1·11 a.u. of undetermined sign). The ratio of the computed to the experimental total molecular energy is found to be 0·9905. Ionization potentials and single-electron excitation energies are computed and compared with experimental spectroscopic values. The spectral results are more encouraging than have been hitherto reported from calculations by the LCAO molecular-orbital method. The approximation of neglecting the inner-outer-shell mixing, as it has usually been done in computations of this type, somewhat changes the present results and is not recommended. A.

539.132

4850. New hybrid π-orbitals of tetrahedral symmetry. G. GIACOMETTI. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 3, 507–8 (*March*, 1954) In Italian.

Theoretical. Tetrahedral π-orbitals are constructed from *p*- and *d*-orbitals; only three linearly independent orbitals can be made orthogonal to each other and to the σ-orbitals, suggesting that 75% is the maximum double bond character possible in compounds like $SO_4^=$, $Ni(CO)_4$. J. HAWGOOD

539.132

4851. The bond orders of alternant hydrocarbon molecules. G. G. HALL. *Proc. Roy. Soc. A*, **229**, 251–9 (*April* 21, 1955).

The equations which determine the molecular orbitals of an alternant hydrocarbon molecule are discussed. It is proved that the bond orders can be calculated algebraically by various methods without solving the eigenvalue equations. In particular, it is possible to express the bond orders as the sum of a converging series of matrices each of whose terms has a simple interpretation. The naphthalene and benzpyrene molecules are used as illustrations of the various methods. These methods are particularly useful when applied to self-consistent field treatments of these molecules. A.

539.132 : 548.7

4852. A quantum theoretical study of the covalent boron-boron bonds in crystals of some metal borides. S. FLODMARK. *Ark. Fys.*, **9**, *Paper* 24, 357–76 (1955).

The electronic distribution around the boron atoms in metal borides with stable space lattices has been theoretically determined and interpreted as covalent bonds in the directions of adjacent boron atoms. Two methods have been used. In the first method the wave-function is assumed to have an extreme value, when the valence electrons of a given boron atom are located in the bond directions. Hydrogen-like atomic orbitals (AO's) have been used. There is reason to believe that the metal atoms are ionized, with the result that every boron atom has between three and four valence electrons instead of three as usual. As it is impossible in this case to compose an antisymmetric wave-function for the electrons of one atom, the electron density has also been determined by the condition of maximum values in the bond directions. Both methods gave the result that the excited 3 *d*-orbitals play an important rôle in describing the bonds, as they make it possible to arrange the electrons according to the crystal symmetry. However, the approximations made probably give an overestimation of this effect. By using the method of maximum density the excited orbitals were found to dominate almost completely. In spite of this, variation of the effective charge parameter of the *d*-orbitals gave interesting results. A.

539.132 : 535.343

4853. Quantitative study of the bonding of chloroform-D in various solvents by infrared spectrometry. R. C. LORD, B. NOLIN AND H. D. STIDHAM. *J. Amer. Chem. Soc.*, 77, *No.* 5, 1365–8 (*March* 5, 1955).

Infrared studies have shown that the intensity of the carbon-deuterium stretching band in chloroform-D increases tenfold or more when the latter is mixed with certain solvents. This increase has been measured quantitatively for diethyl and di-*n*-butyl ethers, *p*-dioxane, anisole, acetone, acetic anhydride, ethyl acetate and pyridine. The association constant for the system diethyl ether–chloroform-D has been found to be $0{\cdot}80 \pm 0{\cdot}15\ l/mole^{-1}$ from the infrared data. A new method of preparation of chloroform-D is described. A.

539.132 : 538.222

4854. The electronic structure and magnetic properties of uranyl-like ions. I. Uranyl and neptunyl. J. C. EISENSTEIN AND M. H. L. PRYCE. *Proc. Roy. Soc. A*, **229**, 20–38 (*April* 5, 1955).

A theory of the electronic bonding in the uranyl ion is given, on the basis of which the paramagnetism of uranyl can be explained. Assuming the same bonding mechanism to be effective in neptunyl, with one unpaired electron, its energy levels, absorption spectrum, paramagnetic resonance and susceptibility are discussed. Agreement with experiment is satisfactory. The evidence points clearly to *f*-electrons being responsible for the magnetism. A.

539.132 : 535.343

Bond moments in formaldehyde. *See Abstr.* 4536

539.132

4855. On the theory of molecular polarization in gases. I. Effect of molecular interactions on the polarizability of spherical nonpolar molecules. L. JANSEN AND P. MAZUR. *Physica*, **21**, *No.* 3, 193–207 (*March*, 1955).

The theory of molecular polarization in dense systems is presented on a quantum mechanical basis for spherical, non-polar molecules. This permits the calculation of the effect of molecular interaction on the polarizability of the molecules, which is considered constant in the statistical theory of the dielectric constant. The interaction Hamiltonian is restricted to the induced dipole term and the polarizability is obtained from perturbation theory as a power series in the interaction tensor $T_{ik} = \nabla_i \nabla_k (1/r_{ik})$ where r_{ik} is the distance between the centres of molecules i and k. As a special case it is shown that in a system of isotropic harmonic oscillators, interacting through induced dipole forces, the polarizability remains constant in any order of approximation. For hydrogen atoms and helium atoms, however, the polarizability increases in the order T^2 due to interactions between pairs of atoms. This effect gives rise to a deviation from the Clausius–Mosotti expression which is of the same form and of the same order of magnitude as the effect of statistical fluctuations. A.

539.132

4856. On the theory of molecular polarization in gases. II. Effect of molecular interactions on the Clausius–Mosotti function for systems of spherical nonpolar molecules. P. MAZUR AND L. JANSEN. *Physica*, **21**, *No.* 3, 208–18 (*March*, 1955).

The results of Pt I are applied to the evaluation of the Clausius–Mosotti function for compressed gases in the density region up to 200 amagat. The Yvon–Kirkwood statistical theory is modified to include the effect of interactions on the polarizability. The result is a series expansion of the Clausius–Mosotti function in powers of the density, the coefficients of which can be expressed in terms of the intermolecular forces. It is shown that for helium atoms the effect of interactions on the polarizability gives a contribution to the Clausius–Mosotti function which is of the same order of magnitude as the effect due to translational fluctuations in the induced dipole moments. The results may also be expected to give good agreement with experimental data for argon. A.

539.133

4857. The computation of electric dipole moments. E. A. GUGGENHEIM. Letter in *Proc. Phys. Soc. [London] B*, **68**, *Pt* 3, 186–7 (*March*); Erratum, *Pt* 4, 253 (*April*, 1955).

Very accurate density measurements are not necessary as they lead only to a more exact value of the partial molal volume of the solute, which is shown to be unnecessary. The author's previous suggestions for simplifying the calculations [Abstr. 1122 (1950)] are explained but regretted because of the confusion which they cause. G. HOWELLS

539.133

4858. Bond angles in water-type and ammonia-type molecules and their derivatives. R. S. MULLIKEN. *J. Amer. Chem. Soc.*, **77**, *No.* 4, 887–91 (*Feb.* 20, 1955).

The factors which may determine the smaller bond angles in the hydrides of the higher-row fifth-column and sixth-column atoms as compared with NH_3 and H_2O, and the much larger energies required to flatten PH_3 and AsH_3 to planar form than for NH_3, are discussed using LCAO molecular orbital and valence bond theory. It is shown that the observed differences can reasonably be understood as a result of *d*-hybridization in the *e*-type or b_2-type bonding molecular orbitals, together perhaps with smaller non-bonded repulsions between H atoms, in the higher-row hydrides. Significant factors affecting the bond angles in the halides of fifth-column and sixth-column atoms are also surveyed. A.

539.133 : 535.343

Dimensions and angles of cyclopentene oxide. *See Abstr.* 4537

539.133 : 537.226.31

4859. Dielectric absorption in phenols with intramolecular hydrogen bonds. R. J. MEAKINS. *Trans Faraday Soc.*, **51**, *Pt* 3, 371–7 (*March*, 1955).

Describes the results of dielectric measurements on *ortho*-substituted phenols in which intramolecular hydrogen bonds would be expected to occur. It is found that most of the phenols with both *ortho*-positions occupied give appreciable dielectric absorption whereas, in the corresponding mono-substituted compounds, absorption is absent. This suggests that the absorption is due to transitions of the hydroxyl group from one hydrogen-bonded position to the other. The energy barriers and the energy differences between equilibrium positions are determined in each case from the temperature variation of the frequency of maximum absorption and the maximum loss factor. The results suggest that, in most of the compounds investigated, the hydroxyl groups in the transition state are considerably influenced by neighbouring molecules. A.

ATOMS . NUCLEUS . ISOTOPES 539.15

539.152.1

4860. Fractional parentage coefficients and their explicit evaluation. A. HASSITT. *Proc. Roy. Soc. A*, **229**, 110–19 (*April* 5, 1955).

In the independent particle model, the total wave-function is expressed as a linear combination of

products of single particle wave-functions. Fractional parentage coefficients give the part of the expression depending on the symmetry properties of the wave-function. An operator is introduced which picks out the antisymmetric part of any n-particle wave-function. The operator is given explicit form, and an explicit formula for the fractional parentage coefficients is deduced. The total fractional parentage coefficients can be split into a part depending on the orbital vectors, and a part depending on the spin (and isotopic spin) vectors. The separate parts can have symmetries other than total antisymmetry. Operators are introduced which pick out states of definite symmetry from any state. The operators are given explicit form, and explicit formulae for orbital, or spin, fractional coefficients are deduced. Detailed results are given for the three, four and five particles cases. A.

539.152.1

4861. On the binding energy and properties of lower energy levels of Li^6. M. Morita and T. Tamura. *Progr. theor. Phys.*, **12**, *No.* 5, 653–88 (*Nov.*, 1954).

By modifying the usual shell model treatment, so as to take into account the correlation of the position co-ordinates of the constituent particles, the binding energy and other properties of the lower energy levels of Li^6 are calculated. Using two-body central and tensor interactions, the parameters of which are adjusted to low-energy two-body data, fairly good agreement with experiment is obtained for the binding energy. However, the splitting between the second excited and the ground states is far too small, because of the large cancellation of the tensor S-D interference terms, and this is reflected in the too large value of the magnetic moment of the ground state. The quadrupole moment is very small, in agreement with experiment, although it might be considered as an incidental agreement. A.

539.152.1

4862. The binding energies of ^3H and ^4He. G. Abraham, L. Cohen and A. S. Roberts. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 265–84 (*April*, 1955).

The binding energies are calculated as part of an attempt to solve the "consistency" problem of light nuclei. A phenomenological two-body interaction, with central and tensor forces of different range, is assumed, the parameters being taken from a paper by Feshbach and Schwinger [Abstr. 74 (1952)]. The inclusion of additional sets of D-states in the wave-functions is found to have a very appreciable effect on the binding energies. A rough calculation shows that the contribution of spin-orbit forces may not be negligible. Without a more extensive investigation into the effects of the additional D-states and the effect of spin-orbit forces, it is impossible to conclude that the interaction used leads to a satisfactory solution of the "consistency" problem. A.

539.152.1 : 535.343 : 537.531

A new determination of the K absorption frequencies of caesium (55) and barium (56). *See Abstr.* 4712

539.152.1 : 539.163.1

4863. The isobaric series Sn^{130}–Sb^{130}. I. Fränz, J. Rodriguez and H. Carminatti. Note in *Z. Naturforsch.*, **10a**, *No.* 1, 86 (*Jan.*, 1955) In German.

Sn^{130}, the parent of the 10 minute Sb^{130}, was produced by the fission of uranium with neutrons or 30 MeV deuterons, and its half-life found to be 57 ± 2 minutes. The chemical separation of the tin fraction from the irradiated uranium is outlined.

J. HUGHES

539.152.2

4864. New arrangements for nuclear resonance with frequency modulation. G. Fischer, R. Beeler, C. Manus, G. Béné, P. Denis and R. Extermann. *Arch. Sci.* [*Geneva*] **7**, *No.* 5, 397–400 (1954) In French.

A ferroelectric condenser, whose capacity varies with an applied modulation signal, is used as part of the resonance circuit of an oscillator for nuclear resonance observations; through its control, with different modulation frequencies and amplitude, a convenient frequency modulation of the oscillator is obtained and rapid passage echo signals are obtained without the use of field modulating coils, which normally occupy a considerable part of the magnetic field volume. D. H. WHIFFEN

539.152.2

4865. Nuclear spin of uranium-235. K. L. Vander Sluis and J. R. McNally, Jr. Letter in *J. Opt. Soc. Amer.*, **45**, *No.* 1, 65–6 (*Jan.*, 1955).

The relative intensities of the h.f.s. components of the $\lambda 6465$ line in the spectrum of U^{235} show that its nuclear spin is 7/2. M. A. GRACE

539.152.2

4866. On the spin of certain odd-odd nuclei. IV. Generalizations. C. Marty, R. Nataf and J. Prentki. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 6, 602–3 (*Feb.* 7, 1955) In French.

For Pt III, see Abstr. 688 (1954). Previous calculations of the energy [Abstr. 6805 (1954)] are generalized to the case of pure j–j coupling. P. T. MATTHEWS

539.152.2

4867. Isotopic spin selection rule for electric dipole transitions. W. M. MacDonald. *Phys. Rev.*, **98**, *No.* 1, 60–5 (*April* 1, 1955).

The validity of the isotopic spin quantum number in nuclei provides a selection rule on electric dipole transitions. The extent to which this selection rule is violated provides a means of experimentally determining the isotopic spin impurity of nuclear states providing that the radiation widths for uninhibited $E1$ radiation can be predicted. The sources of possible variations of $E1$ matrix elements are discussed with reference to the reliability of predicted $E1$ radiation widths in nuclei for $A \leqslant 20$ and excitation energy $\sim$15 MeV. Higher order corrections to the $E1$ selection rules are determined and found to be negligible compared to the effects of isotopic spin impurity, It is concluded that the isotopic spin selection rule on $E1$ transitions provides a sensitive test of charge independence. Isotopic spin impurity determined in this way can be attributed solely to the Coulomb potential. A.

539.152.2

4868. Spins and parities of excited states of Ce^{140} and Sr^{88}. G. R. Bishop and J. P. Perez y Jorba. *Phys. Rev.*, **98**, *No.* 1, 89–94 (*April* 1, 1955).

The angular correlations and the direction-polarization correlations of γ-rays of Ce^{140} and Sr^{88} have been measured. Spins and parities have been assigned to

the excited states of these nuclei as follows: Ce^{140}: 2·42 MeV, 3^-; 2·09 Mev, 4^+; 1·60 MeV, 2^+. Sr^{88}: 2·78 MeV, 3^-; 1·87 MeV, 2^+. A.

539.152.2

4869. Alignment of ^{56}Co nuclei. II. Spin and parity assignments. O. J. Poppema, J. G. Siekman, R. van Wageningen and H. A. Tolhoek. *Physica*, **21**, *No.* 3, 223–32 (*March*, 1955).

For Pt I, see Abstr. 3972 (1955). A theoretical discussion of experimental data on the anisotropies of γ-radiations from aligned Co^{56} nuclei is given in order to obtain spin and parity assignments in the disintegration scheme. The result of the discussion is: Co^{56} (ground state) 4 + (5 +); Fe^{56} ground state 0 +, 0·845 MeV 2 +, 2·09 MeV 4+, 3·14 MeV 3 + (4 +, 3−), 3·44 MeV 3 + (3−), 3·84 Mev 5 ± (3 +, 3−), 4·09 MeV 4 +. The assignments are given after the energy of the level; assignments, which are thought to be less probable, but not quite impossible, are given in parentheses. A.

539.152.2

4870. Experiments on oriented ^{60}Co nuclei. O. J. Poppema, M. J. Steenland, J. A. Beun and C. J. Gorter. *Physica*, **21**, *No.* 3, 233–50 (*March*, 1955).

A survey is given of the investigations on oriented Co^{60} nuclei contained in (Co, Cu, Zn) $(NH_4)_2(SO_4)_2.6H_2O$ crystals. Crystals of three different compositions were used with 0%, 10% and 20% copper respectively. By adiabatic demagnetization the crystals were cooled down to about 0·02°K. During the warm-up the angular distribution of the γ-rays emitted by the Ni^{60} nuclei was measured for different directions of the counters. The essential parts of the experimental set-up are described. The measured anisotropic angular distributions are given as functions of the magnetic temperature T^*. The results are compared with theory. They are in good agreement with the 4-2-0 spin assignment to the Ni^{60} levels concerned. An estimate of the magnetic moment of the Co^{60} nucleus yields a value of 4·3 ± 0·2 nuclear magnetons if one assumes the spin of the Co^{60} nucleus to be 5. A.

539.152.2 : 535.338.332

Determination of the electric quadrupole moments of the Rb^{85} and Rb^{87} nuclei. *See Abstr.* 4520

539.152.2 : 538.222

4871. The nuclear spin and magnetic moment of terbium 159. J. M. Baker and B. Bleaney. Letter in *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 3, 257 (*March*, 1955).

Values $I = 3/2$ and $\mu = 1{\cdot}5 \pm 0{\cdot}4$ n.m. are obtained from the paramagnetic resonance of the $4f^8$, $^7F_6$ ground state of $^{159}Tb^{+++}$ diluted to 0·1% in yttrium ethyl sulphate. $g_{||} = 17{\cdot}72$ and the transition is between the $J_z = +6$ and $J_z = -6$ levels, which are split by admixture with $J_z = 0$.

D. H. Whiffen

539.152.2

4872. Configuration mixing and magnetic moments of odd nuclei. A. Arima and H. Horie. *Progr. theor. Phys.*, **12**, *No.* 4, 623–41 (*Nov.*, 1954).

The deviations of magnetic moments of odd nuclei from the Schmidt lines are calculated by taking into account the effect of departure from the single-particle model in nuclear states caused by configuration mixing. The calculations are based upon simple perturbation theory and the values of the deviations are estimated by adopting the two-body interaction strengths and integrals which are determined from the empirical data on pairing energies. The general trend as well as the fluctuation of the deviations of magnetic moments from the Schmidt lines are accounted for fairly well. A.

539.152.2

4873. Nuclear electric quadrupole moment of Na^{23}. M. L. Perl, I. I. Rabi and B. Senitzky. Letter in *Phys. Rev.*, **97**, *No.* 3, 838–9 (*Feb.* 1, 1955).

The h.f. interaction constants of the $3^2P_{1/2}$ and $3^2P_{3/2}$ states of Na^{23} have been measured by the atomic beam resonance method proposed by Rabi [see Abstr. 8383 (1952)]. For the $3^2P_{3/2}$ state it was not possible to assign uniquely the two observed overlapping resonances to the 3–2 and 2–1 transitions. Hence the two values $+0{\cdot}11$ and $-0{\cdot}91\times10^{-24}$ cm^2 remain possible for Q, though the latter would hardly be accepted by current nuclear theory. L. Pincherle

539.153

4874. Calculation of energy levels of the valence electron in sodium. L. Simons. *Comment. phys.-math.* [*Helsinki*] **17**, *Paper* 7, 10 *pp.* (1955).

A method for numerical integration of the wave equation for the valence electron in hydrogen-like atoms with an outer electron and an electronic core is given. Calculations are carried out for *S*, *P*, *D* and *F* series of sodium, using the Prokofjew central field to approximate the effect of the atomic core upon the valence electron. Results are compared after substituting the Hartree–Fock field for the Prokofjew field. The calculations indicate that the Hartree–Fock field does not provide a good approximation to a central field for the motion of the valence electron. A.

539.153

4875. Two configurational approximation in the case of the configuration $1s^22s^22p3s$ of the carbon atom. G. K. Tsyunaĭtis and A. P. Yutsis. *Zh. éksper. teor. Fiz.*, **25**, *No.* 6(12), 679–82 (1953) In Russian.

The self-consistent Hartree solution for the $1s^22s^22p3s$ configuration is tabulated to 4 decimals. Using this a comparison with the 2-configurational approximation $1s^22s^22p3s$–$1s^22p^33s$ is made. The correction to the energy is $-0{\cdot}042$ atomic units. The theoretical difference of $-0{\cdot}005$ a.u. between the terms ^3P and ^1P (experimental $-0{\cdot}007$ a.u.) remains unchanged. W. J. Swiatecki

539.153

4876. Mass corrections to the hyperfine structure in hydrogen. W. A. Newcomb and E. E. Salpeter. *Phys. Rev.*, **97**, *No.* 4, 1146–58 (*Feb.* 15, 1955).

In a previous paper [Abstr. 7482 (1952)], a covariant wave equation for bound states was used to calculate corrections to fine structure. The techniques developed in that paper are extended here to the study of hyperfine structure (h.f.s.) in the hydrogen atom. An expression is derived for corrections of relative order $(\alpha m/M)$ to the h.f.s. splitting of any *S*-state of hydrogen, arising from the finite mass of the nucleus. The proton is considered as a point particle with an

anomalous magnetic moment of the Pauli type in addition to its Dirac moment. It is shown that the corrections obtained with an unmodified Pauli moment diverge logarithmically, and a cut-off in momentum space is introduced. Numerical results are given for the limit of large cut-off momentum. It is shown that the leading terms, which involve $\log(M/m)$ as a factor, can also be obtained from a modified form of three-dimensional perturbation theory. A.

539.153

4877. Hyperfine structure of He^{3+} and He^3. A. M. Sessler and H. M. Foley. *Phys. Rev.*, **98**, *No.* 1, 6–19 (*April* 1, 1955).

The ratio of the h.f.s. of He^{3+} to H^1 is calculated by taking into account all effects other than the radiative mass corrections, $\alpha m/M$ (h.f.s.), which contribute a relative correction to h.f.s. greater than 10^{-6}. This includes the effect of nuclear structure and internal motion, and also of interaction currents calculated according to various models. Following A. Bohr, structure effects are calculated in the adiabatic approximation, and corrections for non-adiabaticity are included. Nuclear orbital h.f.s. is evaluated by a perturbation theory which proceeds from a non-adiabatic approximation, and a rather simple general expression is obtained for the evaluation of the effect of interaction currents. Corrections are obtained to the h.f.s. of the He^3 ^3S atomic state, as calculated with a non-relativistic wave-function for a point nucleus of infinite mass. These corrections include both the nuclear structure effects for which the analysis of He^{3+} applies, and the relativistic and reduced mass effects characteristic of the two-electron atom. A.

539.153 : 530.145

4878. Excitation of nuclear rotational states in μ-mesonic atoms. L. Wilets. *K. Danske. Vidensk. Selsk., mat.-fys. Medd.*, **29**, *Paper* 3, 22 *pp.* (1954).

The interaction of a μ-meson with the rotational states of nuclei with large deformations produces splittings of the $2p$ mesonic atom energy levels, increasing the number of observed lines. There is a large probability that the nucleus be left in an excited rotational level after the meson reaches the atom *ic* ground state. Level schemes and probabilities of the nucleus being left in an excited state are portrayed for the even-even isotopes $_{72}Hf^{176}$, $_{90}Th^{230}$, and the odd isotope $_{92}U^{235}$. Experimental studies of these effects would give information about the magnitude and sign of intrinsic quadrupole moments and charge distributions. In particular, the sign of intrinsic quadrupole moments of even-even nuclei can be determined; this quantity is not available from other experiments.

G. E. BROWN

539.153 : 535.343 : 537.531

***L* absorption spectra and energy levels of neodymium (60) and samarium (62).** *See Abstr.* 4711

539.154.2

4879. Principal considerations in the periodic system of the elements. Relations between nucleus and [electron] shell. R. Lepsius and S. K. Asunmaa. Note in *Naturwissenschaften*, **41**, *No.* 21, 496–7 (1954) In German.

For previous part, see Abstr. 467 (1955). A rather superficial analogy is drawn between the main and sub-groups of the periodic system and the building-up of nuclei from main groups of equal numbers of neutrons and protons ($N = P$) and sub-groups for which $N = 2P$. A. O. STANESBY

539.154.2

4880. Principal considerations in the periodic system of the elements. XI. Relative abundances. R. Lepsius and S. K. Asunmaa. Note in *Naturwissenschaften*, **42**, *No.* 1, 14 (1955) In German.

Curves are given of the relative abundances *v.* the neutron excess for the stable isotopes of elements, both in the 2nd, "main" group and the 2nd "subsidiary" group of the periodic table. The curves show distinct maxima for particular values of the neutron excess. J. HUGHES

539.154.2

4881. Principal considerations in the periodic system of the elements. Cosmic abundances. S. K. Asunmaa and R. Lepsius. Note in *Naturwissenschaften*, **42**, *No.* 2, 42–3 (1955) In German.

An attempt to bring out regularities in a comparison of abundances with the periodic table of isotopes discussed in Abstr. 9530 (1954).

W. J. Świątecki

539.154.2

4882. The normal electron configurations of atoms. A. S. Ganesan. *Curr. Sci.*, **24**, *No.* 1, 10–11 (*Jan.*, 1955).

Describes a simple mnemonic diagram giving the sequence of filling of electron sub-shells as Z increases.

J. HAWGOOD

539.155.2

4883. Isotopic composition of bromine in nature. A. E. Cameron and E. L. Lippert, Jr. *Science*, **121**, 136–7 (*Jan.* 28, 1955).

Four samples of elemental Br and one of ethylene bromide were converted to NaBr and spectroscopically analysed. No significant variation in the Br^{79}/Br^{81} abundance ratio, as determined from different samples, was observed, the final average being 1·021 7. N. M. KING

539.155.2

4884. On the dependence of the separation effect on the counter-current circulation in the gas centrifuge. H. G. Hertz and E. Nann. *Z. Naturforsch.*, **10a**, *No.* 2, 170–1 (*Feb.*, 1955) In German.

Without making the assumption [cf. Martin and Kuhn, *Z. phys. Chem. A*, **189**, 219 (1940)] that one of the components in a mixture of two isotopes is present in small proportion, a formula giving the isotopic enrichment of a mixture of isotopes in the gas centrifuge is set up which is in good agreement with experiment. W. GOOD

539.155.2 : 537.525

4885. Enrichment of isotopic molecules in the direct current glow-discharge. IV. The primary effect. Determination of the atom concentration in hydrogen and deuterium discharges. H. D. Beckey and P. Warneck. *Z. Naturforsch.*, **10a**, *No.* 1, 62–7 (*Jan.*, 1955) In German.

For Pt III, see Abstr. 2094 (1955). The atom concentrations of H and D in direct current glow-discharges were determined by the slit method as functions of current and pressure. Under equal conditions the maximum relative difference in atom concentration

([D] − [H])/[H] was 19%. The dependence of the atom concentration on the pressure could be calculated theoretically and by comparing it with the experimental results the mechanism of molecular dissociation could be determined. H. LONDON

RADIOACTIVITY . α, β- AND γ-RAYS 539.16

539.16.08 : 550.93

4886. Location of radioactive substances in a rock by application of the method of transparent slices of granite and nuclear emulsions. B. TWAROWSKA. *Acta phys. Polon.*, **13**, *No.* 4, 231–4 (1954) In French.

Studies of specimens of granite indicate that some centres of radioactivity are correlated with zircon inclusions in biotite. The crystalline structure of the biotite is destroyed near the zircon, indicating a possible method of age determination. J. J. WILKINS

539.163.08

4887. A note on mean life-time determinations on small samples of radioactive nuclei. G. EKSPONG. *Ark. Fys.*, **9**, *Paper* 23, 353–5 (1955).

Attention is drawn to a useful relation connecting the mean lifetime for radioactive decay with the distribution in time of individual disintegrations. M. A. GRACE

539.163.1

4888. A measurement of the period of ThB (Pb^{212}). J. TOBAILEM AND J. ROBERT. *J. Phys. Radium*, **16**, *No.* 2, 115–18 (*Feb.*, 1955) In French.

An account of an accurate determination of the mean-life, 10·643 ± 0·012 hours, of ThB using a differential arrangement of two ionization chambers. M. A. GRACE

539.163.1

4889. Half-life of Rb^{86}. J. B. NIDAY. *Phys. Rev.*, **98**, *No.* 1, 42 (*April* 1, 1955).

A number of very pure samples of Rb^{86} obtained by a new radiochemical procedure were found to have a half-life of 18·64 ± 0·04 days. A.

539.163.1

4890. Redetermination of the disintegration constant of U^{238}. A. F. KOVARIK AND N. I. ADAMS, JR. *Phys. Rev.*, **98**, *No.* 1, 46 (*April* 1, 1955).

A recount of α-particles from previously used specimens of natural uranium gives $1{\cdot}538 \times 10^{-10}$ yr^{-1} for the disintegration constant of U^{238}. A.

539.163.2

4891. The decay scheme and β-spectrum of natural actinium. W. BECKMANN AND E. HUSTER. Note in *Z. Naturforsch.*, **10a**, *No.* 1, 82–3 (*Jan.*, 1955) In German.

The end point of the β-spectrum was found to be 45·5 ± 1 keV, from proportional counter measurements. No evidence was found for the 37 keV γ-ray reported by earlier workers. J. HUGHES

539.163.2

4892. The disintegration of Rh^{105}. J. LABERRIGUE-FROLOW. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 3, 287–9 (*Jan.* 17, 1955) In French.

The complex β^--spectrum of Rh^{105} has been resolved into two components (intensity ratio 2 : 1) with $E_{max} = 560 \pm 5$ and 247 ± 5 keV, both showing the allowed form. Although a γ-ray of 310 ± 5 keV was found there was no indication ($<10^{-3}$/disintegration) of that of 62·5 keV which is excited in the decay of Ag^{105} to the same residual nucleus. M. A. GRACE

539.163.2

4893. A study of the disintegration scheme of Ba^{133}. M. LANGEVIN. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 3, 289–91 (*Jan.* 17, 1955) In French.

Coincidence scintillation counter measurements of the X- and γ-radiation have been used to confirm the decay scheme proposed earlier [Abstr. 7698 (1954)] and to identify the character of the γ-rays: 362 keV (*E*2), 290 keV (*M*1), 82 keV (*M*1) and 72 keV (*M*1). Since the total *K* X-radiation can be accounted for by internal conversion it is concluded that *L* capture is the principal mode of decay. M. A. GRACE

539.163.2

4894. On the disintegration of Hg^{203}. N. MARTY. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 3, 291–4 (*Jan.* 17, 1955) In French.

Beta-spectrometer measurements show that the β-spectrum ($E_{max} = 214 \pm 2$ keV) has allowed form, the ground-state transition being undetectable ($<4 \times 10^{-5}$) and from the values of α_K (0·205 ± 0·01) and α_K/α_L (3·15 ± 0·15) that the 279 keV γ-ray is a mixture (30% *M*1, 70% *E*2). M. A. GRACE

539.163.2

4895. A note on the disintegration of Tl^{204}_{81}. T. YUASA AND J. LABERRIGUE-FROLOW. Letter in *J. Phys. Radium*, **16**, *No.* 2, 165–6 (*Feb.*, 1955) In French.

From the absence of a low energy β-transition in the decay of Tl^{204} (<5% of that to the ground state) and from the γ-ray energies known from the decay of isomeric Pb^{204} it is suggested that the first excited state of Pb^{204} is at 890 keV. M. A. GRACE

539.163.2

4896. Decay of Co^{57}. L. MADANSKY AND F. RASETTI. Letter in *Phys. Rev.*, **97**, *No.* 3, 837–8 (*Feb.* 1, 1955).

Gamma-ray measurements using scintillation counters combined with measurements in which Co^{57} is included within a NaI (Tl) crystal suggest that the 14 keV γ-ray precedes that of 120 keV. Decay takes place mainly by *K* capture to the 120 keV state (90%) while only 10% excites the 14 keV γ-ray which has a ½-life $\geqslant 10^{-6}$ sec. M. A. GRACE

539.163.2

4897. Disintegration scheme of copper-62 and its relation to recent mass measurements. J. M. REID AND I. F. WRIGHT. Letter in *Nature* [*London*] **175**, 298 (*Feb.* 12, 1955).

No evidence (<5%) for γ-radiation (0·1–1·2 MeV) in coincidence with positrons in the decay of Cu^{62} has been found. Attention is drawn to discrepancies between direct mass measurements and those obtained by nuclear disintegration. M. A. GRACE

539.163.2

4898. Decay of the 3·5-min metastable state of Sb^{122}. J. M. LEBLANC, J. M. CORK AND S. B. BURSON. *Phys. Rev.*, **98**, *No.*1, 39–40 (*April* 1, 1955).

The radiations associated with the 3·5 min activity of Sb^{122} have been studied with 180° magnetic photographic spectrometers and a ten-channel coincidence

scintillation spectrometer. Two γ-rays with energies of 60·7 and 75·3 keV were detected by means of internal conversion electrons and also by means of the scintillation spectrometer. The 75·3 keV transition is the more strongly converted of the two, and it is concluded that it is the isomeric transition. The two γ-rays are emitted in cascade. A.

539.163.2

4899. Decay of Y^{91}. B. KAHN AND W. S. LYON. *Phys. Rev.*, **98**, *No.* 1, 58–9 (*April* 1, 1955).

Yttrium-91 was observed to decay with a half-life of 57·5 ± 0·5 days. In addition to the 1·55 MeV β-transitions, 0·22 ± 0·01% of the Y^{91} decay consists of a 0·36 ± 0·02 MeV β-group in coincidence with a 1·190 ± 0·005 MeV γ-ray. A.

539.163.2

4900. Radioactivity of Co^{57}. B. CRASEMANN AND D. L. MANLEY. *Phys. Rev.*, **98**, *No.* 1, 66–8 (*April* 1, 1955).

Co^{57} (270-day) has been prepared by the reactions $Mn^{55}(\alpha,2n)$ and $Ni^{58}(p,2p)$, separated chemically, and its disintegration studied with a magnetic lens and a scintillation spectrometer. Co^{57} decays by electron capture; an upper limit of 2×10^{-5} positron per disintegration has been set. Positron groups previously assigned to Co^{57} presumably belong to one of the neighbouring isotopes of cobalt. Gamma rays of 0·137 and 0·123 MeV have a relative abundance of 7 and 93%, and presumably are $E2$ and $M1$ transitions, respectively. A decay scheme is outlined. A.

539.163.2

4901. Iridium-194. C. E. MANDEVILLE, J. VARMA AND B. SARAF. *Phys. Rev.*, **98**, *No.* 1, 94–9 (*April* 1, 1955).

Electromagnetically enriched quantities of Ir^{193} were exposed for time intervals ranging from 0·5 to 2·0 hr on five successive occasions in the Brookhaven pile. The 19 hour Ir^{194} was found to emit γ-rays of energies 0·295, 0·325, 0·635, 0·640, 0·93, 1·14, 1·28, 1·45, 1·58, 1·77, and ~2·00 MeV. By coincidence studies, cascade relationships were established between ten pairs of γ-rays. The first and second excited states of the residual nucleus were located at 325 and 620 keV. The angular correlation function of the 0·295 MeV–0·325 MeV cascade was measured and found to correspond to a 2→2→0 distribution, thus giving the spins of the first two excited states of Pt^{194}. A.

539.164

4902. An approximate but simple experimental law for the α-disintegration energy of the heavy radioactive elements. F. ROGER. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 8, 858–9 (*Feb.* 21, 1955) In French.

The α-disintegration energy E is given as the following function of the nuclear neutron and proton numbers N and Z resp.,

$$E(\text{MeV}) = 9 - \left(\frac{N-128}{6}\right)\left(\frac{102-Z}{6}\right),$$

for $Z \geqslant 84$ and $N \geqslant 128$. J. HUGHES

539.164 : 539.166

4903. The α–γ and α–X-ray angular correlations in Io (Th_{90}^{230}). G. VALLADAS, J. TEILLAC, P. FALK-VAIRANT AND P. BENOIST. *J. Phys. Radium*, **16**, *No.* 2, 125–35 (*Feb.*, 1955) In French.

The angular distribution of monoenergetic α-particles from a source deposited on one plate of an ionization chamber can be determined by analysis of their pulse-heights. In coincidence with a scintillation counter this has been used to measure for a metallic source the angular correlation for α_1–γ_1 (67·8 keV) which is attenuated through electric quadrupole interaction; this shows the spins of the levels to be 0,2,0. Similarly for α_2–γ_2 (142 keV) these spins are 0,4,2. An isotropic correlation was found for α_1 and the L X-rays following internal conversion of γ_1. A full discussion is given. M. A. GRACE

539.164 : 539.166

4904. Alpha and gamma spectra of Cf^{246}. J. P. HUMMEL, F. S. STEPHENS, JR, F. ASARO, A. CHETHAM-STRODE, JR AND I. PERLMAN. *Phys. Rev.*, **98**, *No.* 1, 22–4 (*April* 1, 1955).

The α and γ spectra of Cf^{246} have been studied with an α-particle spectrograph and γ-ray scintillation spectrometer. Alpha groups of 6·753 MeV (78%) and 6·711 MeV (22%) were observed. L X-rays and γ-rays of ~100 keV ($1\cdot4\times10^{-2}$%) and ~44 keV were assigned to Cf^{246}. These results are evaluated with respect to the developing theory and systematics of complex α spectra and excited states of even-even nuclei. A.

539.164.08 : 537.542

Alpha-ray spectroscopy by ionization pulse analysis. *See Abstr.* 4754

539.165

4905. An investigation of the longitudinal angular distribution of photoelectrons at gamma ray energies of 0·41, 0·66 and 1·33 MeV. S. HULTBERG. *Ark. Fys.*, **9**, *Paper* 15, 245–80 (1955).

Using a double-focusing spectrometer together with Au, Pb and U radiators, photo-line heights and widths were studied as functions of angle. The angles of maximum emission differ slightly from theoretical values. J. J. WILKINS

539.165 : 537.533.35

The beta spectrum of Cs^{137}. *See Abstr.* 4724

539.165.2

4906. Beta-ray spectra. I. H. TAKEBE. *Progr. theor. Phys.*, **12**, *No.* 5, 561–73 (*Nov.*, 1954).

Probabilities of β-decay transitions forbidden to any degree have been calculated in the case of linear combination of Fermi interactions, with some corrections taken into account. A.

539.165.2

4907. Beta-ray spectra. II. H. TAKEBE. *Progr. theor. Phys.*, **12**, *No.* 5, 574–7 (*Nov.*, 1954).

The relation between the many-particle and the single-particle matrix element is calculated in the jj coupling scheme. A.

539.166

4908. Some explicit formulae for the angular distribution and polarisation of gamma radiation emitted by oriented nuclei. C. D. HARTOGH, H. A. TOLHOEK AND S. R. DE GROOT. Letter in *Physica*, **20**, *No.* 12, 1310–13 (*Dec.*, 1954).

Formulae are given for (*a*) the angular distribution, (*b*) the polarization and (*c*) the change in the orientation parameter f_k for mixed dipole and quadrupole radiation with $\Delta j = 0, \pm1$, and (*a*) and (*c*) for

octupole radiation with $\Delta j = \pm 2, \pm 3$ [see Abstr. 7527 (1952), 7100 (1953)]. W. J. SWIATECKI

539.166

4909. Theorem on angular correlation. S. RABOY AND V. E. KROHN. *Phys. Rev.*, **98**, *No.* 1, 24–5 (*April* 1, 1955).

In a multiple cascade, the angular correlations between a γ-ray and each of two following or preceding γ-rays are shown to be equal for the following conditions: (1) The two observed γ-rays not common to both pairs must have the same multipolarity and must result from basic transitions. (2) If the two observed γ-rays not common to both pairs have unobserved γ-rays between them, these unobserved γ-rays must come from basic transitions. (3) The transitions subject to the first two conditions must take place between levels with spins in monotonic sequence. A.

539.166

4910. On the ^{60}Ni gamma-gamma directional correlation function. S. COLOMBO, A. ROSSI AND A. SCOTTI. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 3, 522–3 (*March*, 1955).

An accurate measurement of this was made and found to agree with the theoretically calculated values for an undisturbed 4 ($E2$) 2 ($E2$) 0 cascade. J. HUGHES

539.166

4911. The γ-rays of Tc^{95}. V. S. SHPINEL'. Letter in *Zh. éksper. teor. Fiz.*, **27**, *No.* 3, 387–8 (1954) In Russian.

The photoelectron spectrum from deuteron-irradiated Mo was measured with a lens spectrometer. From observations at varying times after irradiation, photoelectron lines corresponding to γ-rays of 762, 932 and 1 071 keV, could be assigned to Tc^{95}. J. HUGHES

539.166

4912. Gamma rays in the decay of ^{112}Pd and ^{112}Ag. R. H. NUSSBAUM, A. H. WAPSTRA, M. J. STERK AND R. E. W. KROPVELD. Letter in *Physica*, **21**, *No.* 1, 77–8 (*Jan.*, 1955).

Scintillation spectrometer measurements confirm the existence of an $18{\cdot}5 \pm 0{\cdot}5$ keV ray in the Pd^{112} spectrum. Eight rays between 0·62 and 2·79 MeV were resolved in the Ag^{112} spectrum. J. J. WILKINS

539.166

4913. On the 113 keV level in Lu^{175}. N. MARTY. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 9, 963–5 (*Feb.* 28, 1955) In French.

A γ-ray of 113 keV ($\alpha_K = 2{\cdot}35 \pm 0{\cdot}4$) excited in the decay of Yb^{175} and associated with that of 282 keV has been identified by scintillation counters. The intensity of this cascade is $0{\cdot}58 \pm 0{\cdot}05$ that of the cross-over transition (396 keV). M. A. GRACE

539.166

4914. Gamma rays of 100^{254}. F. ASARO, F. S. STEPHENS, JR, S. G. THOMPSON AND I. PERLMAN. *Phys. Rev.*, **98**, *No.* 1, 19–21 (*April* 1, 1955).

Gamma-rays of 42 ± 4 (2×10^{-20}%) and 94 ± 2 keV ($2{\cdot}8 \times 10^{-20}$%) were found in coincidence with α-particles of 100^{254}. The L X-rays (from the internal conversion of the 42 keV γ-ray) were measured and from the intensity the population of the first excited state was calculated to be 15 ± 2%. The γ-rays are interpreted as cascading transitions resulting from the de-excitation of Bohr–Mottelson rotational states having spins of 2 and 4, even parity. The abundances of the α transitions to the spin 4 states of even-even nuclides in this region (after normalizing for differences in energy separation from the ground state) exhibit a pronounced minimum for curium emitters and progressively increase for emitters of higher and lower atomic number. A.

539.166

4915. Radiations of Mo^{90} and the isomeric states of Nb^{90}. H. B. MATHUR AND E. K. HYDE. *Phys. Rev.*, **98**, *No.* 1, 79–84 (*April* 1, 1955).

Gamma-gamma coincidence measurements of the radiations of 5·7 hour Mo^{90} showed that the 120 and 250 keV γ-rays previously reported by Diamond were delayed. Further experiments showed the existence of a 24 second isomer of Nb^{90} emitting 120 keV γ-rays and a 10 to 20 millisecond isomer emitting 250 keV γ-rays. The transition types were not assigned unambiguously but the 24 second isomer is probably $E2$ and the 10 to 20 millisecond isomer $E3$ or $M3$ in nature. The radiations of the 14·6 hour ground state of Nb^{90} were also studied. The 140 keV and 1·14 MeV γ-rays are in coincidence with each other and with annihilation radiation. A prominent 2·2 MeV γ-ray is not in coincidence with annihilation radiation or X-rays. Hence, it must be a delayed transition with $\Delta I \geqslant 3$. This is of interest because of the rarity of such transitions in even-even nuclei. A.

539.166

4916. Gamma ray energy spectrum from iron bombarded by 14 MeV neutrons. S. HAYAKAWA AND K. KIKUCHI. *Progr. theor. Phys.*, **12**, *No.* 5, 578–84 (*Nov.*, 1954).

This is calculated on the basis of the compound nucleus formalism. The cross-sections for various competing processes are found to be considerably dependent upon the magnitude of temperature. Three values of a, the quantity closely related to temperature, have been assumed. Although they are based upon the experimental evidences of different sources, none of them is found to be able to account for the experimental energy spectrum. There seems to remain a difficulty in the statistical theory pointed out by Cohen. A.

539.166

4917. Gamma rays from the reaction ^{27}Al (p,γ) ^{28}Si. M. HATTORI, K. HISATAKE, T. MIKUMO AND T. MOMOTA. Note in *J. Phys. Soc. Japan*, **10**, *No.* 3, 242–3 (*March*, 1955).

Using 986 keV incident protons, the energies of eight γ-rays between 4·5 and 12·1 MeV have been determined by means of deuterium-loaded emulsions. J. J. WILKINS

539.166 : 539.172.13

4918. Gamma rays from the deuteron bombardment of carbon-13. R. J. MACKIN, JR, W. B. MIMS AND W. R. MILLS, JR. *Phys. Rev.*, **98**, *No.* 1, 43–6 (*April* 1, 1955).

A magnetic-lens spectrometer was used to investigate the γ-radiation produced by the deuteron bombardment of C^{13} enriched carbon targets. A study of

the Compton electron spectra from a thin Al convertor at $E_d = 1{\cdot}42$ MeV revealed the following γ-lines (energies in keV, not corrected for possible Doppler shift): 4930 ± 40, 5130 ± 30, 5730 ± 30, 6120 ± 25. A weak line at 3910 ± 50 keV was established with the spectrum from a thick Al convertor. At $E_d = 1{\cdot}9$ MeV, additional lines appeared at 6450 ± 50, 6730 ± 40, and 811 ± 3 keV. The last-named was identified by photoelectrons from a thorium convertor. No new lines were discovered at $E_d = 2{\cdot}7$ MeV. The well-known 6·12 MeV line is from C^{14*}, as are probably the 6·73 and 0·811 MeV lines. All others correspond to known levels of N^{14}.

A.

539.166.08

4919. Measuring high doses by absorption changes in glass. J. H. SCHULMAN, C. C. KLICK AND H. RABIN. *Nucleonics*, **13**, *No.* 2, 30–3 (*Feb.*, 1955).

Experimental investigations on changes in light absorption coefficients, induced by γ-radiation in unactivated and Ag-activated phosphate glasses, are described. Absorption coefficients increase linearly with exposure up 10^5 rep, but the increase with dosage above about 2×10^6 rep is very low. The response is energy-dependent at low energies (below 200 keV), but not significantly dependent on dose rate. Fading of the coloration of the irradiated glass on storage can be almost eliminated by a mild heat treatment.

L. R. SHEPHERD

539.166.08

4920. How drill-hole diameter affects gamma-ray intensity. S. C. HYMAN, B. MINUSHKIN AND J. CERTAINE. *Nucleonics*, **13**, *No.* 2, 49–50 (*Feb.*, 1955).

Experiments with a scintillation detector inside cylindrical holes, drilled through bodies of radioactive ore, showed that the measured radiation intensity was independent of hole diameters between 2 in. and 12 in., the solid angle of the radioactive wall subtended at the detector being kept constant in each case. This result was confirmed by theoretical analysis.

L. R. SHEPHERD

539.166.08 : 537.542

4921. Proportional gamma spectrometer. D. G. MILLER. *Nucleonics*, **13**, *No.* 2, 58–60 (*Feb.*, 1955).

Characteristics of a proportional counter used as a γ-spectrometer were investigated experimentally for various gas fillings, namely, CO_2 with A, CH_4 with A and He with isobutane using K X-rays ranging from 5·9 keV (Fe^{55}) to 24·1 keV (Sn^{113}). Highest resolutions were obtained with the CH_4/A filling.

L. R. SHEPHERD

539.166.08 : 541.15

4922. Dosimetry of γ-radiation from a nuclear reactor by irradiation of ferrine. J. PUCHEAULT. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 7, 772–4 (*Feb.* 14, 1955) In French.

Ferrine (ferric orthophenanthroline) is reduced by γ-rays to ferroine (ferrous orthophenanthroline). An "after-effect" due to formation of a peroxide is included. $G_\gamma = 12{\cdot}5$ (Co^{60} radiation). G_α (radon α-particles) for the same system is about 1, and a similar value is assumed for photons and recoil nuclei in the pile. Experiments in which (i) H_3BO_3 was added to the ferrine solutions, (ii) ferrine and ceric sulphate solutions were irradiated simultaneously in the same container, show that the γ- and α-yields are additive. Ferrine can thus be used for dosimetry of γ-radiation in the pile, and comparison of results with those obtained by ionization methods shows that the γ-ray energy absorbed in water or in aqueous solutions from pile radiation can be determined in this way to within 10%.

C. B. ALLSOPP

539.166.74

4923. Scattering of 1·33 MeV γ-rays by the electric field of nuclei. L. GOLDZAHL AND P. EBERHARD. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 9, 965–8 (*Feb.* 28, 1955) In French.

The elastic scattering of Co^{60} γ-radiation was measured at several angles for Pb. The differential cross-sections are smaller than those calculated for Rayleigh and Thompson scattering and the difference is attributed to scattering of opposite phase due to the nuclear electric field.

M. A. GRACE

539.166.74

4924. Simultaneity in the Compton effect. Z. BAY, V. P. HENRI AND F. MCLERNON. *Phys. Rev.*, **97**, *No.* 6, 1710–12 (*March* 15, 1955).

The simultaneity in the Compton effect has been investigated by using scintillation counters and fast coincidence techniques. By the use of a γ-ray source of a known, very short, lifetime (Ni^{60}) it was possible to apply a first moment investigation to the time delays involved. It is shown that the order of magnitude of all possible time delays involved in the Compton effect does not exceed 10^{-11} second. Upper limits previously given were $\sim 10^{-8}$ second.

A.

539.166.75

4925. Analysis of scintillation spectrometer observations of the penetration of Cs^{137} gamma radiation through water. R. B. THEUS, L. A. BEACH AND W. R. FAUST. *J. appl. Phys.*, **26**, *No.* 3, 294–7 (*March*, 1955).

Spectral modifications of Cs^{137} γ-radiations produced by penetration and diffusion through water have been observed. A single crystal of NaI(Tl) was used to observe the pulse-height distributions produced by radiation from both plane parallel and point isotropic sources. Inversion of the pulse-height distribution was carried out by use of an analogue computer to obtain the spectral distribution of radiation.

A.

539.166.83

4926. New treatment of the Auger effect and the fluorescence yield in the lighter elements. R. A. RUBENSTEIN AND J. N. SNYDER. *Phys. Rev.*, **97**, *No.* 6, 1653 (*March* 15, 1955).

A new treatment of the Auger effect using methods made available by modern high-speed digital computers is reported. These results have been used to evaluate the fluorescence yield in the lighter elements A, Kr, and Ag. The results, 0·13, 0·67, and 0·85 respectively, compare very favourably with the best available experimental values.

A.

539.166.835

4927. The angular correlation of annihilation radiation. K. L. ERDMAN. *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 4, 304–11 (*April*, 1955).

The departure from exact 180° angular correlation

of quanta resulting from positrons annihilating in various materials have been measured. This provides data as to the momenta of the centres of mass of the annihilating electron-positron pairs. It does not appear possible to account for the data on the assumption that the positron achieves thermal energy by lattice collisions before annihilating, so that such measurements may not be simply related to the momentum distribution of the more loosely bound electrons in the absorbing substance. A.

NUCLEAR REACTIONS 539.17

539.172

4928. Nomogram for estimating nuclear reaction energies. A. E. S. Green. *Nucleonics*, **13**, *No.* 2, 34–7 (*Feb.*, 1955).

A new empirical expression for mass defects is given. This is used to calculate the energies released or absorbed in various nuclear reactions and the results are presented in the form of a nomogram. Expressions are given for a correction that must be made to account for pairing instability and for the quadratic correction. L. R. SHEPHERD

539.172

Nuclear reactions due to cosmic rays. *See also under* "Cosmic rays." Decimal classification 537.591.8

539.172

4929. Nuclear interactions of *K*-mesons. R. R. Daniel and D. Lal. *Proc. Indian Acad. Sci. A*, **41**, *No.* 1, 15–24 (*Jan.*, 1955).

Fast *K*-mesons (τ- as well as K_μ-mesons) with energies between 150 and 250 MeV can cause nuclear disintegrations and lose a substantial fraction of their kinetic energy without losing their identity. The characters of the interaction in three of the four cases discussed here exhibit a remarkable degree of similarity. The nuclear capture of a *K*-meson at rest is discussed. The nature and distribution of prongs in the capture star suggest that a Λ^0-hyperon may have been formed during the capture process. A.

539.172 : 537.533.74

Scattering of 192-MeV electrons from the deuteron. *See Abstr.* 4728

539.172.13

4930. The total cross sections for the nuclear scattering of high energy nucleons. K. M. Gatha and G. Z. Shah. Letter in *Proc. Phys. Soc.* [*London*] *A*, **68**, *Pt* 3, 259–60 (*March*, 1955).

Using a method similar to that described in Abstr. 11317 (1954) and a complex Gaussian potential well, total cross-sections at 340 MeV have been calculated for Be, C, O, Al, S. W. J. SWIATECKI

539.172.13

4931. Excitation functions for some proton-induced reactions of thorium. H. A. Tewes. *Phys. Rev.*, **98**, *No.* 1, 25–8 (*April* 1, 1955).

The excitation functions for the (p,f), (p,n), and $(p,3n)$ reactions on thorium have been determined for proton energies up to 32 MeV. A.

539.172.13

4932. Angular distributions and yields of neutrons from (p,n) reactions. B. L. Cohen. *Phys. Rev.*, **98**, *No.* 1, 49–55 (*April* 1, 1955).

Angular distributions of neutrons from (p,n) reactions on Mg, Al, Cu, Mo, Ag, Ta, Au, Th, and U were measured for 23 MeV protons incident on thick targets. All angular distributions show peaks in the forward direction; except for Mg and Al, the 0°/180° intensity ratios vary from 5 to 15 for ~13 MeV neutrons, and from 1·3 to 5 for ~8 MeV neutrons. The Mg and Al high-energy data show minima and secondary maxima. Yield determinations indicate that the number of neutrons per nuclear reaction increases with atomic number from about 0·25 for Mg and Al to about 2·0 for most heavy elements and more than 4 for Th and U (probably due to fission). Temperatures of the neutron energy distributions are estimated; for the heavy elements at the backward angles, they are about 0·85 MeV at 3 MeV neutron energy, and about 1·9 MeV at 10 MeV neutron energy, and about 1·9 MeV at 10 MeV neutron energy. It is concluded that direct interactions are of considerable importance in these reactions. A.

539.172.13

4933. High-energy proton spallation-fission of uranium. R. L. Folger, P. C. Stevenson and G. T. Seaborg. *Phys. Rev.*, **98**, *No.* 1, 107–20 (*April* 1, 1955).

The fission and spallation reactions produced in uranium by bombardment with high-energy protons (340 to 350 MeV) were investigated. The reaction products were separated from the target by chemical processes and identified by their radioactive properties. The relative yields of the observed fission products are calculated, and the results plotted as a function of mass number. Several of the spallation products are identified and their yields estimated. An attempt is made to determine the most probable atomic number for a nuclide of given mass formed directly from fission. Studies are made of the relative yields along several isobaric chains as a function of atomic number. From these data, estimates of the mass and charge of the fissioning nucleus are made. By using the reaction $Al^{27}(p,3pn)Na^{24}$ of known cross-section to monitor the bombarding beam, the absolute formation cross-sections for several fission product nuclides were measured. Values for these reference nuclides are used to transform all the relative yields into formation cross-sections. Summation integration over the range of mass numbers of the area under the plot of formation cross-sections as a function of mass number leads to a value of 2·0 barn for the total fission cross-section for uranium bombarded with high-energy protons, if one assumes binary fission. A.

539.172.13

4934. Angular distribution of disintegration products from the $O^{16}(d,p)O^{17}$, $Be^9(d,p)Be^{10}$ and $Be^9(d,t)Be^8$ reactions. M. K. Jurić. *Phys. Rev.*, **98**, *No.* 1, 85–8 (*April* 1, 1955).

The angular distributions of disintegration products from the reactions $O^{16}(d,p)O^{17}$, $Be^9(d,p)Be^{10}$, and $Be^9(d,t)Be^8$ were examined, with deuteron energies from 0·60 to 1·45 MeV. Pronounced asymmetry is

found with respect to 90°. The results are analysed to determine the relative contributions of stripping and compound nucleus formation. A.

539.172.13

4935. Excitation function of $O^{16}(t,n)F^{18}$. N. JARMIE. *Phys. Rev.*, **98**, *No.* 1, 41–2 (*April* 1, 1955).

The excitation function of the reaction $O^{18}(t,n)F^{18}$ has been measured for triton bombarding energies of 0·680 to 2·130 MeV. The half-life of the F^{18} β-decay has been measured to be 111 ± 1 min. A.

539.172.13

4936. Reaction $D(t,\alpha)n$ at 1·5 MeV. A. HEMMENDINGER AND H. V. ARGO. *Phys. Rev.*, **98**, *No.* 1, 70–2 (*April* 1, 1955).

The differential cross-section for the reaction $D(t,\alpha)n$ has been measured at 10° intervals from 10° to 140° in the laboratory system for a triton energy of 1·5 MeV. The total cross-section is 280 ± 8 mb. A.

539.172.3

4937. Evidence for an independent particle state of C^{12} at high excitation. A. K. MANN, W. E. STEPHENS AND D. H. WILKINSON. Letter in *Phys. Rev.*, **97**, *No.* 4, 1184–5 (*Feb.* 15, 1955).

The angular distribution of protons from the $C^{12}(\gamma,p)B^{11}$ reaction at the giant resonance (22 MeV) favours an independent particle description of this state and suggests that the coupling is of the *LS* type. M. A. GRACE

539.172.3

4938. (γ,p) and (γ,n) yield ratios from self-conjugate nuclei. H. MORINAGA. Letter in *Phys. Rev.*, **97**, *No.* 4, 1185 (*Feb.* 15, 1955).

Calculation of these ratios on the basis of compound nucleus formation shows that for light elements proton emission is the predominant mode of decay. M. A. GRACE

539.172.3

4939. Yield of photoprotons from some light elements. S. A. E. JOHANSSON. Letter in *Phys. Rev.*, **97**, *No.* 4, 1186 (*Feb.* 15, 1955).

Integrated cross-sections (to 28 MeV) have been determined for Mg, Si, S and Ca. The results indicate that proton emission is the predominant mode of decay. J. J. WILKINS

539.172.3

4940. Photodisintegration of the deuteron. Y. YAMAGUCHI AND Y. YAMAGUCHI. *Phys. Rev.*, **98**, *No.* 1, 69–70 (*April* 1, 1955).

The electric dipole cross-section for $\gamma(d,p)n$ is examined, assuming no forces in ^3P states. The non-vanishing D-state probability P_D of deuteron gives rise to the isotropic part a_e in angular distribution of the photoproton: $d\sigma/d\omega = a_e + b_e\sin^2\theta$. It turns out, however, that the resulting value for a_e is still small to explain the experimental cross-section, even if P_D is as large as 8%. A.

539.172.3

4941. Absolute cross section for the reaction $C^{12}(\gamma,n)C^{11}$. W. C. BARBER, W. D. GEORGE AND D. D. REAGAN. *Phys. Rev.*, **98**, *No.* 1, 73–6 (*April* 1, 1955).

The activation curve for the reaction $C^{12}(\gamma,n)C^{11}$ was obtained with the use of both the Mark II (38 MeV) and Mark III (630 MeV) linear accelerators, covering the energy range 18–260 MeV. Stacked foils of polystyrene detectors and tantalum and copper radiators were exposed to the direct electron beam and the resulting C^{11} activity was measured with a 4π scintillation counter. The photon flux was obtained from the measured electron flux by means of the Bethe–Heitler theory of bremsstrahlung, and the photon-difference method was applied to obtain the cross-section curve. This curve was found to be similar to some previous results, but with the addition of a high-energy tail extending beyond 38 MeV. The experimental accuracy does not permit a precise determination of the shape of this tail, but it cannot be accounted for by mesonic effects alone. The cross-section has a peak value of about 8·3 millibarn at 22·5 MeV, and integrated values of 0·056 ± 0·003 and about 0·080 ± 0·01 MeV-barn when the integrals are carried up to 38 and 250 MeV, respectively. These numerical values were obtained from the data obtained by using a copper radiator. The corresponding results with a tantalum radiator are about 7% lower, indicating a possible failure of the bremsstrahlung formula for high atomic numbers. A.

539.172.3

4942. Photodisintegration of carbon-12 by 330-MeV bremsstrahlung. S. D. SOFTKY. *Phys. Rev.*, **98**, *No.* 1, 173 (*April* 1, 1955).

The excitation function for the reaction $C^{12}(\gamma,3\alpha)$ from 330 MeV bremsstrahlung has been measured. Ilford C2 600μ emulsions were irradiated and scanned for three-prong stars which satisfied conservation of momentum for the disintegration. Of the forty-six stars found, none were from quanta bigger than 42 MeV and so an upper limit for the cross-section was estimated up to 100 MeV. From this it can be seen that there are no prominent resonances up to 100 MeV other than those already known. A.

539.172.4

4943. The disintegration of ^{7}Be by slow neutrons. R. C. HANNA. *Phil. Mag.*, **46**, 381–92 (*April*, 1955).

The reaction $Be^7(n,p)Li^7$ has been identified for neutrons incident with thermal energies. The cross-section has been measured as $5·3 \pm 0·8 \times 10^{-20}$ cm^2. The cross-section for the reaction $Be^7(n,\alpha)He^4$ does not exceed 1 barn. The results show the parity of Be^7 to be odd. The activity of Be^7 source has been diminished by neutron bombardment. The cross-section for all processes leading to the destruction of Be^7 is found to be $4·8 \pm 0·9 \times 10^{-20}$ cm^2. A comparison of the $Be^7(n,p)Li^7$ and $Li^7(p,n)Be^7$ cross-sections gives evidence for a level in Be^8 near the neutron threshold of width not exceeding 30 keV. A.

539.172.4

4944. $(n,2n)$ cross section of Na^{23} at 14·1 MeV. R. J. PRESTWOOD. *Phys. Rev.*, **98**, *No.* 1, 47–9 (*April* 1, 1955).

An experimental determination of this cross-section was made on six individual samples and involved the use of 4π counting, low-background counting, neutron monitoring and sample thickness corrections. The value obtained is 13·8 ± 2·2 millibarn and the error quoted is twice the standard deviation obtained from

the six samples. The experimental work is described in detail and a discussion of the possible errors is given. A.

539.172.4

4945. Correction to the exponential dependence of neutron transmissions. R. G. THOMAS. *Phys. Rev.*, **98,** *No.* 1, 77–8 (*April* 1, 1955).

If the energy spread of the neutron source used in a transmission type of measurement of total neutron cross-sections is large compared with the mean spacing of the resonance levels of the sample, these levels may effect a deviation from the simple exponential dependence on sample thickness. The correction to this dependence is derived in the case where capture, inelastic scattering and Doppler broadening may be neglected. The derivation does not depend upon any special assumption regarding the distributions of the widths and spacings of the levels other than that they have suitable averages, and the correction is found to be proportional to the ratio of these averages, as one would expect. It is noted that by measurement of this ratio for certain elements, it may be possible to distinguish between the predictions of the strong-coupling and complex-square-well representations of the neutron-nucleus interaction. A.

539.172.4

4946. Energy dependence of the U^{235} fission cross-section. D. POPOVIĆ AND N. RAJŠIĆ. Letter in *J. nuclear Energy*, **1,** *No.* 2, 170 (*Dec.*, 1954).

The ratio of the fission cross-section to the boron (n, α) cross-section has been measured from 0·01 to 0·40 eV. A resonance occurs at about 0·28 eV.

J. M. CASSELS

539.172.4

4947. Fast-fission cross-sections of U^{235} and U^{238}. N. RAIŠIC. *Nucleonics*, **13,** *No.* 2, 67–8 (*Feb.*, 1955).

A comparison of counting rates was made, between natural and enriched U-fission counters and a BF_3 counter, in a fission neutron flux. A value of 0·091 b was assumed for the $B(n, \alpha)$ reaction in the fission neutron spectrum and the fission cross-sections were then found to be $0{\cdot}27 \pm 0{\cdot}03$ b and $1{\cdot}6 \pm 0{\cdot}8$ b for U^{238} and U^{235} respectively. L. R. SHEPHERD

539.172.4

4948. Determination of the characteristics of the neutron spectrum from a nuclear reactor. D. D. POPOVIĆ. *Bull. Inst. Nuclear Sci.* "*Boris Kidrich*," **4,** 83–8 (*June*, 1954).

The neutrons emerging from the central irradiation channel of the Norwegian heavy-water reactor "Jeep" were analysed. A crystal spectrometer was used to determine the thermal neutron temperature. The epithermal flux was related to the total neutron density by making cadmium ratio measurements with a thin boron counter. The relationship between the fast and thermal fluxes was obtained by measurement of the fission yields produced by the epithermal and fast components respectively. These two components were separated by selective absorption. D. R. CHICK

539.172.4

4949. Reactor control-rod theories. R. L. MURRAY AND J. W. NIESTLIE. *Nucleonics*, **13,** *No.* 2, 18–22 (*Feb.*, 1955).

The critical conditions of cylindrical thermal reactors with cylindrical absorbers (inserted fully or withdrawn), located coaxially, are calculated on the basis of a two-group theory. Both bare and reflected systems are considered. The estimated reactivity controlled by the rod is in reasonable agreement with experiments, if suitable assumptions are made for the boundary conditions of the fast neutron flux at the surface of the absorbing rod. L. R. SHEPHERD

539.172.4

4950. A study of the non-linear kinetics of the Chatillon reactor. I. Theory. H. J. LIPKIN. *J. nuclear Energy*, **1,** *No.* 3, 203–13 (*Feb.*, 1955).

The non-linear dynamics of a heterogeneous reactor is considered by extending the treatment of Weinberg and Ergen. The new features present in the heterogeneous case are discussed, and results and conclusions are obtained for comparison with experiments performed on the Chatillon reactor. A.

ATOM AND MOLECULE BEAMS . MESONS NEUTRONS 539.18

539.18

4951. Search for a much idealized theory of the hyperons. G. HEBER. *Z. Naturforsch.*, **10a,** *No.* 2, 103–9 (*Feb.*, 1955) In German.

The hyperons are identified with the isobaric states, predicted by Tomonaga's intermediate coupling theory of a non-relativistic, scalar, nucleon in interaction with a scalar meson field. A reasonable choice of coupling strength gives qualitatively the correct mass spectrum, but no explanation is found for the observed long life-times. P. T. MATTHEWS

539.18

4952. Excited states of very short life-time and charge invariance. B. D'ESPAGNAT. *C.R. Acad. Sci.* [*Paris*] **240,** *No.* 2, 164–6 (*Jan.* 10, 1955) In French.

It is shown that the more direct consequences of charge invariance and the formation of intermediate excited nucleon states in meson production are only valid for reasonably long life-times of the excited states. As an example, meson production in $\pi^+ - p$-collisions is discussed. G. FIELD

539.18

4953. Selection rules for decays into spin 0 and polarized spin 1 particles due to the conservation of angular momentum and parity. B. JAKŠIĆ. *Period. math.-phys. astron.* [*Zagreb*] **9,** *No.* 2, 81–7 (1954).

The derivation of a list of selection rules for decays into 2 particles whose spins are (*a*) both 0, (*b*) 0 and 1, (*c*) both 1 (particles distinguishable), (*d*) both 1 (particles indistinguishable). Account is taken explicitly of the state of polarization. The method used involves constructing all possible wave-functions.

W. J. SWIATECKI

539.18

4954. Contribution to the τ-meson investigation. E. AMALDI, G. BARONI, G. CORTINI, C. FRANZINETTI AND A. MANFREDINI. *Nuovo Cimento Suppl.*, **12,** *No.* 2, 181–94 (1954).

Four examples of τ-mesons observed in stripped emulsion exposed at balloon altitudes in Sardinia

are reported. For these four events, the weighted average of the Q-values is $74{\cdot}2 \pm 0{\cdot}5$ MeV, and of the τ-meson mass is $964{\cdot}5 \pm 1{\cdot}1\, m_e$. Information so far collected on the spin, parity and mean life of τ-mesons is discussed. The frequency of τ-decay compared to the frequency of $\pi^{\pm}$ coming to rest inside the emulsion is given as $N\tau/N\pi = 3{\cdot}3 \times 10^{-3}$.

P. ROTHWELL

539.18

4955. Analysis of some τ-mesons. G. BELLIBONI, B. SECHI AND B. VITALE. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 195–201 (1954).

Three τ-mesons have been observed in stripped emulsion decaying at rest into three charged π-mesons; also a fourth event, which is probably an example of an alternative mode of τ-decay into one charged π-meson and two neutral particles. The weighted average of the Q-value for the three τ-mesons is $75{\cdot}4 \pm 0{\cdot}8$ MeV, and the mass $m_\tau = 967{\cdot}1 \pm 2{\cdot}0\, m_e$. The production, and charge of τ-mesons which decay at rest, and the energy spectrum of the decay pions are discussed, taking into account 25 events observed in various laboratories.

P. ROTHWELL

539.18

4956. An example of a τ^+ and of a $(\tau)K_\pi^+$. M. DI CORATO, C. C. DILWORTH AND L. SCARSI. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 202–4 (1954).

Details of these two events are given; the range, energy and mass (measured by the constant sagitta method) of the τ-particles, and the range, energy and sign of the secondary particles. The Q-value of the τ^+ is given as $73{\cdot}2 \pm 3$ MeV. P. ROTHWELL

539.18

4957. The phenomenological treatment of τ-meson decay. E. FABRI. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 205–6 (1954).

The decay pattern of the τ-meson is represented on a triangular diagram (the distances of a point P, inside the triangle, from the sides of the triangle are proportional to the kinetic energies of the three π-mesons), and divided into three classes, according to whether the energy of the unlike π-meson is larger, intermediate, or smaller than that of the other two. The relative probabilities for the three classes of decay pattern are calculated for the five cases of spin and parity, $[0-]$, $[1+]$, $[1,-]$ $[2,+]$ $[3,-]$, of the τ-meson. P. ROTHWELL

539.18

4958. Observation of τ-mesons. T. F. HOANG, L. JAUNEAU, G. KAYAS, L. LEPRINCE-RINGUET, D. MORELLET, A. ORKIN-LECOURTOIS, G. TARIEL AND J. TREMBLEY. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 208–9 (1954) In French.

In a systematic scanning of $24\,\text{cm}^3$ of stripped emulsion exposed at balloon altitude, two τ-mesons and a τ'-meson have been observed. Details of the two τ-events are tabulated. The mass of the τ', measured by four different methods, photometric, blob-counting, grain density and scattering is compatible with that of the τ. The τ'-event is interpreted as $\tau^{+\prime} \rightarrow \pi^+ + \pi^0 + \pi^0$. P. ROTHWELL

539.18

4959. Contribution to the K-meson investigation. E. AMALDI, G. CORTINI AND A. MANFREDINI. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 210–19 (1954).

Four K-mesons and two hyperons have been found in a systematic scanning of a stack of stripped emulsions exposed at balloon altitudes, in which all events consisting of two tracks showing appreciably different grain densities were examined. A detailed description of the procedure followed in grain-density and scattering measurements is given. The weighted average of the mass of the K-mesons, $m_K = 930 \pm 20\, m_e$. Details of measurements on all six particles are tabulated, also details of the stars in which the K- and τ-mesons and hyperons originated.

P. ROTHWELL

539.18

4960. Observations on K-meson decays. M. BALDO, G. BELLIBONI, B. SECHI AND G. T. ZORN. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 220–2 (1954).

Eight heavy mesons, coming to rest and decaying into minimum ionizing particles have been observed in two stacks of stripped emulsion exposed at balloon altitude. The identity of the particles was established through multiple-scattering measurements at the end of their ranges in the emulsion. A detailed analysis has been made of each event; the origin and mass of the heavy meson, the $p\beta$ and (where possible) the mass of the secondary, and details of the nuclear disintegration from which the K-particle was emitted are reported and discussed. P. ROTHWELL

539.18

4961. Measurements on K-mesons. J. K. BØGGILD, J. E. HOOPER AND M. SCHARFF. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 223–6 (1954).

Eight heavy mesons have been observed, in a systematic scanning of photographic plates, exposed at balloon or aeroplane altitudes, for particles which come to rest and decay, or cause a star. Details of measurements made on these events are reported. A special device for making gap counts, which increases the speed and reproducibility of measurements, is described. P. ROTHWELL

539.18

4962. Mass and decay of K-particles. A. BONETTI, R. L. SETTI, B. LOCATELLI AND G. TOMASINI. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 227–30 (1954).

Seven K-mesons decaying at rest into a single charged secondary have been found in plates and stripped emulsions exposed at balloon altitudes. Results of the measurements made on these seven events, together with six other events reported previously, are given in a table. The mass measurements on the primaries of the K-mesons were made by the constant sagitta method; a histogram of the distribution in sagitta of K- and Y-particles decaying at rest, and of calibration protons shows indications of peaks around sagitta corresponding to $950\, m_e$ and $2\,300\, m_e$, with a considerable intensity from 1 000 to $1\,500\, m_e$.

P. ROTHWELL

539.18

4963. Investigation on grey tracks of particles ejected from energetic nuclear explosions. R. R. DANIEL, A. KRISHNAN, S. MITRA AND Y. PAL. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 231–5 (1954).

A hyperon, a K-meson, and two particles which

may be hyperons have been found in a systematic scanning of stripped emulsions. Details of measurements made on these particles are given.

P. ROTHWELL

539.18

4964. Mass measurements by the ionization *versus* scattering method, on fast particles emerging from nuclear disintegrations. P. H. FOWLER AND D. H. PERKINS. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 236–9 (1954).

Mass determinations on the fast charged particles emerging from nuclear disintegrations have been carried out by combined measurements of multiple scattering and ionization. Provisional results are given for five deuterons, two hyperons, 112 protons, nine particles of mean mass $1450\,m_e$, and two K-particles of mass $970 \pm 100\,m_e$ and $1030 \pm 50\,m_e$ respectively. It is uncertain whether the group of particles at mass value 1450 is due to a different particle of mass less than a proton or if it arises from something inherent in the experimental method employed. P. ROTHWELL

539.18

4965. Some speculations on the nature of the K_μ-particle. U. HABER-SCHAIM. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 240–1 (1954).

The K_μ two-body decay scheme, $K_\mu \rightarrow \mu + \nu$ is compared with the decay of the pion. It is suggested that both pions and K_μ-mesons may be coupled to the nucleon with the same strength. The calculated life-times of the two particles are then nearly correct. However, if the K_μ is a pseudoscalar particle which cannot decay into two pions, but which may decay into three $K \rightarrow 3\pi$ or $K_\mu \equiv \tau$. Calculation on the same lines as before gives the τ-life-time as 10^{-14} instead of 10^{-9}. This may mean that the method for calculating the τ-life-time is not correct, or else that a different explanation is needed for K_μ-decay.

P. ROTHWELL

539.18

4966. Results on K^+ mesons. T. F. HOANG, L. JAUNEAU, G. KAYAS, A. ORKIN-LECOURTOIS, L. LEPRINCE-RINGUET, D. MORELLET, G. TARIEL AND J. TREMBLEY. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 242–4 (1954) In French.

Results of systematic measurements, on $1020\,\pi\pm$, $17\,K^+$, two τ^+ and one τK_π (or τ') mesons, found in $24\,\text{cm}^3$ of stripped emulsions exposed at balloon altitudes, are summarized and the methods of measurement briefly indicated. P. ROTHWELL

539.18

4967. A decay curve of K-particles. L. MEZZETTI AND J. W. KEUFFEL. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 245–6 (1954).

Time lags between the pulse from a directional Cherenkov counter, and the pulse from a liquid scintillation counter have been measured for penetrating events produced in a layer of lead placed above these counters. The interpretation of the delay distribution thus obtained, is that certain unstable particles are produced in the lead which decay at rest with emission of an ionizing relativistic secondary (detected when it crosses the Cherenkov counter in an upward direction). The mean life-time obtained agrees with cloud-chamber estimates on the decay times of mesons heavier than π's. P. ROTHWELL

539.18

4968. On the mass of fast K-particles. S. ROSENDORF, R. STAHL, AND G. YEKUTIELL. *Nuovo Cimento Suppl.*, **12**, *No.* 2, 247–9 (1954).

The masses of 35 particles whose tracks in nuclear emulsions had blob densities between 1·05 and 1·50 plateau value, were found by multiple-scattering and grain-density measurements. A statistical argument was applied to show that the data obtained are consistent with one of the two assumptions: (1) The 35 particles consist of two mass groups: 22 protons with average mass $1780 \pm 62\,m_e$, and 13 K-particles with average mass $1220 \pm 50\,m_e$, or (2) they consist of three mass groups; 18 protons with average mass $1820 \pm 64\,m_e$, 12 K-particles average mass $1310 \pm 55\,m_e$, and 5 K-particles with average mass $1600 \pm 77\,m_e$. P. ROTHWELL

539.18

4969. Evidence for the charged θ-meson. M. V. K. APPA RAO and S. MITRA. *Proc. Indian Acad. Sci.*, *A*, **41**, *No.* 1, 30–5 (*Jan.*, 1955).

A K-meson is found to decay at rest into a nearly relativistic secondary particle. The secondary particle produces a nuclear disintegration in flight and is identified as a π-meson of kinetic energy $\sim$110 MeV. The event is interpreted as the decay of a $\theta^\pm$-meson according to the scheme: $\theta^\pm \rightarrow \pi^\pm + \pi^0 + (222 \pm 12\,\text{MeV})$. A.

539.18

4970. Further evidence for the electron-decay of K-mesons. R. H. W. JOHNSTON AND C. O'CEALLAIGH. *Phil. Mag.*, **46**, 393–400 (*April*, 1955).

An event is described in which a K-meson decays at rest to a particle at plateau ionization which has the properties of an electron of $p\beta c \sim 80$ MeV. This brings to three the number of K-mesons in which the charged decay product is apparently an electron. A.

539.18

4971. Example of τ^+-decay in flight. J. R. BURWELL, R. W. HUGGETT AND R. W. THOMPSON. *Phys. Rev.*, **98**, *No.* 1, 101–2 (*April* 1, 1955).

A τ^+-meson, of 0·83 BeV/c, is observed to undergo normal decay in flight with $Q(3\pi) = 73{\cdot}9 \pm 5{\cdot}8$ MeV. The centre-of-mass kinetic energies are found to be $T' = 24{\cdot}3 \pm 1{\cdot}8$ and $28{\cdot}7 \pm 1{\cdot}8$ MeV for the two positive pions and $T' = 20{\cdot}9 \pm 4{\cdot}3$ MeV for the negative pion. A.

539.18

4972. Mesonic decay of an ejected triton. H. YAGODA. *Phys. Rev.*, **98**, *No.* 1, 153–7 (*April* 1, 1955).

A heavy fragment is ejected from a star of type $21 + 5p$ which decays at rest into three charged particles. Gap counts indicate that the ejected fragment is singly charged and heavier than a proton. The mass of the particle, as estimated by constant sagitta scattering along its range of 1330 microns, is $2{\cdot}93 \pm 1{\cdot}36$ proton masses. All three secondary particles terminate their range, and one of them can be identified as a negative π-meson of $26{\cdot}6 \pm 0{\cdot}9$ MeV kinetic energy. Two short recoil tracks, if assumed

to be protons, have kinetic energies of $1{\cdot}43 \pm 0{\cdot}04$ and $2{\cdot}31 \pm 0{\cdot}15$ MeV, respectively. Momentum balance applied to several decay schemes suggest that the event probably represents $H^{3*} \rightarrow H^1 + H^1 + n^0 + \pi^- + Q = 31{\cdot}5 \pm 1$ MeV. The binding energy of the excited triton is found to be $5{\cdot}4 \pm 1$ MeV, less than that of the normal triton (8·48 MeV). The time of flight of the excited triton is $4{\cdot}2 \times 10^{-11}$ sec. A.

539.18

4973. Interaction of π-mesons in photographic plates. L. Ferretti and E. Manaresi. Letter in *Nuovo Cimento* (*Ser.* 10) **1**, *No.* 3, 512–16 (*March*, 1955).

Gives the results obtained from scattering measurements in 600μ plates of π-mesons from the Chicago cyclotron. The data are arranged in four groups, π^+ and π^- each in two energy ranges 5–10 and 10–20 MeV. H. ELLIOT

539.18

4974. On the pair production of hyperons and heavy mesons. K. Gottstein. Note in *Naturwissenschaften*, **42**, *No.* 2, 42 (1955) In German.

A $28 + 29p$ event found in stripped emulsions exposed for 7 hr at 27 km included a τ-meson with its three decay pions ($m_\tau = 963 \pm 0{\cdot}5\, m_e$, life-time 2×10^{-10} sec, kinetic energy 63 MeV) and a hyperon $Y^\pm \rightarrow \pi^\pm$ (or $\mu^\pm$) $+ n + Q$, decaying in flight after 4×10^{-11} sec ($m_Y = 2374 \pm 33\, m_e$, $Q = 135 \pm 17$ MeV). W. J. SWIATECKI

539.18

4975. Pion-pair production in a nuclear emulsion. H. Yagoda. *Phys. Rev.*, **98**, *No.* 1, 103–4 (*April* 1, 1955).

A positive and a negative π-meson pair of tracks with energies of 17·94 and 18·65 MeV, respectively, are observed to originate in an emulsion without any other associated ionizing particles. It is shown that the event probably did not originate from a nuclear collision. Among the mechanisms considered are materialization from a photon, the decay of a θ-meson, and decay of a (previously postulated) η-meson. The Q-value of the event, computed as a 2-body decay is 27·9 MeV. If it is a two-body decay the mass of the parent particle is about $600\, m_e$. This event is also consistent with the decay of a neutral τ-meson into a neutral pion and two charged pions for which the total kinetic energy of the charged mesons could vary between 0 and about 80 MeV. A.

539.18

4976. Production of heavy unstable particles by 1·37-BeV pions. W. B. Fowler, R. P. Shutt, A. M. Thorndike and W. L. Whittemore. *Phys. Rev.*, **98**, *No.* 1, 121–30 (*April* 1, 1955).

Five additional events interpreted as the production of heavy unstable particles by 1·37 BeV pions have been observed in a hydrogen-filled diffusion cloud chamber. In each case the observations are most naturally interpreted as due to the associated production of a hyperon and K-meson. These and earlier observations can be made consistent with known hyperon and K-meson masses if the reaction $\pi^- + p \rightarrow \Sigma^0 + \theta^0$ is assumed to be a possibility with an immediate γ-decay $\Sigma^0 \rightarrow \Lambda^0 + \gamma$ as suggested by Gell-Mann and Pais. The total cross-section for production of heavy unstable particles is estimated to be about 0·9 millibarn. The five new events confirm the previous indications that the Λ^0's tend to be emitted backwards in the centre-of-mass system of the initial collision and to decay in a plane at a small angle to that of the production plane. The orientations of Λ^0's from the wall also support these angular correlations. A.

539.18 : 778.34

4977. On the determination of the mass of unstable heavy particles by photometry of their tracks in nuclear emulsions. L. van Rossum. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 7, 747–9 (*Feb.* 14, 1955) In French.

The photometric method described in a previous paper [Abstr. 8166 (1953)] is shown to be capable of measuring heavy-particle masses with an accuracy of about 6%. A. J. EGGINTON

539.185

4978. The linear extrapolation length at the surface of an imperfectly absorbing cylinder. R. J. Royston. *J. nuclear Energy*, **1**, *No.* 3, 194–9 (*Feb.*, 1955).

The neutron density in a non-capturing medium surrounding an imperfectly absorbing, non-scattering cylinder is calculated by the spherical harmonics method in the P_3-approximation. The linear extrapolation length of the asymptotic neutron density is then deduced from this for various absorbing powers of the cylinder. A.

539.185

4979. Polarization of neutrons in high energy scattering. T. Eriksson and W. J. Swiatecki. *Ark. Fys.*, **9**, *Paper* 16, 281–5 (1955).

The polarizations produced in the scattering of 150 MeV neutrons at various angles by copper have been calculated by the WKB method. The nucleus was represented by a complex square-well potential, with constants indicated by neutron total cross-sections at the same energy. In addition two alternative strengths of spin-orbit coupling potential were assumed to act uniformly throughout the nuclear volume. With these assumptions the polarization was found to be peaked at angles near the diffraction minima. J. M. CASSELS

539.185

4980. The influence of hindered rotation on the scattering of slow neutrons by bound protons. W. Kołos. *Bull. Acad. Polon. Sci. Cl.* 3, **2**, *No.* 9, 423–7 (1954).

Calculations are presented of the molecular cross-section of methyl alcohol, including the effect of inelastic scattering of the neutrons with excitation of rotational levels. The results do not agree well with experiment, and it is suggested that this is largely because the effect of molecular vibration was neglected. J. M. CASSELS

539.185 : 548.7

4981. Measurement of the energy of very slow neutrons after inelastic scattering by polycrystals and monocrystals. B. Jacrot. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 7, 745–7 (*Feb.* 14, 1955) In French.

A mechanical velocity selector was used to select only those neutrons from a pile with energies of the order of several MeV. The energy spectrum of the

neutrons scattered from polycrystalline specimens of Be, Al, Cu and Pb and a Cu monocrystal was measured by a time-of-flight method. The results for Be and Cu are given graphically. J. HUGHES

539.185.08

4982. The use of the $^3T(d, n)^4He$ reaction for a comparison of some methods for the absolute measurement of a fast neutron flux. The yield of a Ra-α-Be source. K.-E. LARSSON. *Ark. Fys.*, **9**, *Paper* 18, 293–333 (1955).

The α-particles emitted from a tritium target bombarded by low-energy deuterons were counted in order to measure the production rate of the associated 14 MeV neutrons. This calibrated neutron source was used to check neutron flux measurements made with a polyethylene-walled ethylene ionization chamber, which was found to give a current $1{\cdot}03 \pm 0{\cdot}04$ times that expected. The source was also used to calibrate BF_3 counters detecting the neutrons moderated in oil and water. Comparison showed that 25% of the 14 MeV neutrons were lost by capture in oxygen while slowing down in water. The moderator and BF_3 counter apparatus, so calibrated, was used to measure the strength of a Ra–Be source, giving a result in good agreement with that obtained by other methods. J. M. CASSELS

STRUCTURE OF SOLIDS 539.2

539.211

4983. Cleavage in the $A^{III}B^V$ compounds InSb and AlSb. H. PFISTER. Note in *Z. Naturforsch.*, **10a**, *No.* 1, 79 (*Jan.*, 1955) In German.

Diamond cleaves on (111) planes, ZnS on (110) planes. Experiments on InSb and AlSb, which have the same structure as these, show that they cleave along (110) planes although they are considerably less ionic in nature than ZnS. W. M. LOMER

539.217 : 539.16

4984. The penetration of concrete by radionuclides in solution. L. H. GEVANTMAN AND D. SAM. *Canad. J. Technol.*, **33**, *No.* 2, 122–7 (*March*, 1955).

The penetration of concrete by the Cs^{134}, Nb^{95}, Ru^{106}, Ce^{144} and I^{131} in solution is measured. Diffusion constants for Cs^{134} and I^{131} are calculated. The values obtained are compared with those measured by Spinks in neat cement and mortar. A.

539.217.1

4985. Pore-size distribution in collagen and leather by the porosimeter method. R. R. STROMBERG. *J. Res. Nat. Bur. Stand.*, **54**, *No.* 2, 73–82 (*Feb.*, 1955).

The pore-size distribution in collagenous tissue and a number of leathers, in the range 100 to 20 000 Å in radius, has been determined by means of a mercury-pressure porosimeter. The sources of error incurred in such measurements, the reliability of the measurements, and experimental and "actual" pore-size distributions are considered. The geometry of the fine and gross structure of leather, and the process of water-vapour transmission through leather are interpreted from the data. A.

539.219

4986. The distribution of bismuth in cast and recrystallized copper. K. TOMAN AND V. PETRŽÍLKA. *Czech. J. Phys.*, **5**, *No.* 1, 57–9 (*Feb.*, 1955).

By investigating the distribution of bismuth in copper-alloys using the radioisotope $^{210}_{83}RaE$ it has been found that in recrystallized copper no precipitation of the bismuth occurs on the grain boundaries during the recrystallization of the copper. A.

539.219.2

4987. The cracking of layers of brittle material by differential strains. D. J. MILLARD. *Brit. J. appl. Phys.*, **6**, *No.* 4, 124–7 (*April*, 1955).

The cracking of a brittle layer of elastic material due to differential straining has been investigated with a view to discovering what factors govern the pattern of the cracks produced by a given strain pattern. An analysis of the stress equations leads to the conclusion that two dimensionless parameters only are involved, the ratio of the applied strains to the breaking strain and the ratio of the crack spacing to the layer thickness: the shape of the curve relating these parameters is deduced by physical argument. Evidence in support of the analysis is obtained from the observed cracking of brittle beams when subjected to a uniform strain gradient by bending. A.

539.231

4988. A method for the preparation of thin films of plutonium and uranium. K. M. GLOVER AND P. BORRELL. *J. nuclear Energy*, **1**, *No.* 3, 214–17 (*Feb.*, 1955).

Fission counters and foils uniformly coated with plutonium and uranium are required for nuclear measurements. A technique is described in which the plutonium or uranium is dissolved in a cellulose lacquer. This lacquer is painted on to the foils and the fission counters are coated by dipping them into this solution. A.

539.232

4989. Study of the oxides of copper formed in air. K. R. DIXIT AND V. V. AGASHE. *Z. Naturforsch.*, **10a**, *No.* 2, 152–60 (*Feb.*, 1955).

Oxides of copper formed in air at temperatures between 150°C and 1 030°C, and for times of formation up to one hour, have been studied. Their composition, structure by electron reflection, and rectification have been investigated as a function of the thickness of the film. At first small crystallites of Cu_2O are formed, then they increase in size and get oriented. These crystallites of Cu_2O gradually change over to those of CuO showing a three-ring pattern, definite orientation and finally a fibrous structure. At high temperatures and appreciable times of formation a layer of Cu_2O is formed below the CuO layer. Rectification of CuO films showing orientation and of the composite film $Cu_2O + CuO$ has been studied in detail. A plausible mechanism for the formation of the various oxides is suggested. The following special points have been observed: (1) Cu_2O changes into CuO, crystallite by crystallite; (2) the three-ring pattern is due to oriented monoclinic CuO; (3) CuO oriented shows a small rectification in a direction opposite to that of Cu_2O; (4) at

high temperatures, when a change of orientation of CuO can occur, a Cu_2O film is formed below the CuO film; (5) the composite layer $Cu_2O + CuO$ shows a rectification comparable with Cu_2O but with a higher voltage response. A.

539.234

4990. Preparation of free (without substrate) metal films. P. A. Il'chenko. *Zh. tekh. Fiz.*, **24**, *No.* 6, 1136–8 (1954) In Russian.

Describes a method for the preparation of thin (down to $0{\cdot}02\mu$) metal films of diameters 20–30 mm by evaporation of the metal on to a celluloid substrate. To prevent rupture of the film during the removal of the substrate, the outer rim of the film is made thicker (by deposition of the metal in two stages), and a thin coating of NH_4Cl is deposited on it by sublimation in vacuum. The NH_4Cl is subsequently removed by sublimation or by dissolution. J. A. SPINK

539.234

4991. The surface areas of evaporated metal films. B. M. W. Trapnell. *Trans Faraday Soc.*, **51**, *Pt* 3, 368–70 (*March*, 1955).

Surface areas per unit weight of Ni, Fe, Rh, Mo, Ta and W films prepared in two different ways have been measured. From these, fractions of the total evaporated atoms present in the films surfaces are calculated. These fractions are shown to be determined mainly by the melting point of the metal, but to some extent by the sintering caused by radiant heat from the evaporating filament. A.

539.26

4992. Study of low-angle X-ray scattering by cellulose (ramie) at different humidities. P. Antzenberger and G. Fournet. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 4, 421–2 (*Jan.* 24, 1955) In French.

539.27

4993. Ion bombardment-cleaning of germanium and titanium as determined by low-energy electron diffraction. H. E. Farnsworth, R. E. Schlier, T. H. George and R. M. Burger. Letter in *J. appl. Phys.*, **26**, *No.* 2, 252–3 (*Feb.*, 1955).

Non-metallic surface structures on Ge and Ti may be removed by bombardment with argon ions in a low-pressure discharge. The resulting surface is shown, by low-energy electron diffraction, to have the desired metallic structure. J. THEWLIS

539.27

4994. Systematic research on contrast modifiers by selective staining in electron microscopy. M. Locquin. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 7, 741–2 (*Feb.* 14, 1955) In French.

A number of organic stains, commonly used in cytological and histological studies, were tested as "electron stains." The increase in contrast of stained specimens, using a phase-contrast light microscope, was found to be proportional to the increase in contrast of electron micrographs using the same stains, and to be dependent on the concentration of heavy metal in the dye molecule. Much improved contrast of electron micrographs was obtained, however, with metal inorganic stains, amongst which cobalt stannate, thallium nitrate and iodine (applied in various forms) proved to be the best. A.E.I. RESEARCH LABORATORY

539.27 : 539.232

4995. The examination of oxide films by reflection electron microscopy. J. S. Halliday and W. Hirst. Note in *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 3, 178–81 (*March*, 1955).

The difference in the frictional behaviour of oxide films on metals is related to the surface topography of these films as revealed by reflection electron microscopy. Films on copper, formed at high temperature, show lumps and blisters whereas those formed at room temperature are relatively flat. This is consistent with the higher coefficient of friction of the former. J. THEWLIS

539.27 : 621.385.833 : 621.389

4996. Exposure timer for the electron microscope. F. W. Bishop. *Electronics*, **28**, *No.* 3, 206–7 (*March*, 1955).

An electronic timer which operates beam-deflecting coils placed between the electron gun and condenser of an electron microscope is described. A thyratron-operated relay circuit with interlocks ensures that the photographic plates are exposed without shutter vibration, and that double exposures are avoided. A.E.I. RESEARCH LABORATORY

ELASTICITY . STRENGTH . RHEOLOGY
539.3/.8

539.32

4997. Elastic constants of aluminum from 20°C to 400°C. C. Zucker. *J. Acoust. Soc. Amer.*, **27**, *No.* 2, 318–20 (*March*, 1955).

The use of the ultrasonic pulse technique as a means of determining the elastic constants of polycrystalline aluminium at high temperatures has been considered in some detail The C_{11} and C_{44} elastic constants, Debye temperature and Young's modulus were computed from the longitudinal and transverse velocity measurements. The variations of these constants with temperature showed the predicted linear decrease expected from solid state theory. A.

539.32 : 535.415

4998. Method of determining the elastic constants of glass. J. Rabinovitch and J. Marcatand. *Rev. Opt.*, **34**, *No.* 2, 103–5 (*Feb.*, 1955) In French.

The use of Newton's rings for the measurement of small deformations is well known and this method is applied to the evaluation of the elastic constants of some samples of glass. A.

539.32 : 536.71

4999. Equation of state of metals from shock wave measurements. J. M. Walsh and R. H. Christian. *Phys. Rev.*, **97**, *No.* 6, 1544–56 (*March* 15, 1955).

Shock-wave pressure magnitudes from about 150 to 500 kilobars have been attained for metals by using high explosives. A photographic technique for the nearly simultaneous determination of shock and free surface velocities is presented, and measurements for aluminium, copper and zinc are given.

Expressions are derived which permit the calculation of pressure-compression points from measured velocity pairs. Consequent Hugoniot curves are presented, probable errors for which are 1 to 2% in compression for a given pressure. Finally, the known Hugoniot curves are employed in a calculation which determines temperatures and isotherms. A.

539.32 : 541.64

5000. Transition temperature of polymethyl methacrylate at ultrasonic frequencies. P. HATFIELD. Letter in *Nature* [*London*] **174**, 1186–7 (*Dec.* 25, 1954).

The possible reasons for discrepancies between the results of various workers. Different samples of commercial plastics are likely to vary, while heating during measurements can cause irreversible changes. Great care must be taken in the amount of energy used and the possibility of transmission of ultrasonics from the sample into surrounding liquid allowed for. T. C. TOYE

539.374

5001. [Spring-dashpot] models for the viscoelastic behaviour of high-polymer materials. T. GAST. *Z. angew. Phys.*, **7**, *No.* 2, 82–6 (1955) In German.

These and their electrical analogues are discussed for tension, shear and hysteresis experiments.

J. E. CAFFYN

539.374

5002. A molecular approach to the problem of viscoelasticity. A. H. NISSAN. Letter in *Nature* [*London*] **175**, 424 (*March* 5, 1955).

Using a Morse potential function, a non-linear stress strain curve is deduced for materials in which the bonds between fibres are almost entirely hydrogen bridges; the two constants of the curve can also be calculated from non-rheological data. J. E. CAFFYN

539.434

5003. The effect of alpha-particle bombardment on the creep of cadmium single crystals. M. J. MAKIN. *J. nuclear Energy*, **1**, *No.* 3, 181–93 (*Feb.*, 1955).

The effect of α-particle bombardment on the creep of cadmium single cystals at room temperature has been measured in an attempt to repeat the observations of Andrade. No significant change in creep rate on initiation of the bombardment has been detected, although experiments were made on crystals differing in purity, surface condition and orientation. It is considered that the increase in creep rate observed by Andrade was either due to geometrical softening or to the disruption of a surface film of somewhat critical thickness. A.

539.622

5004. The mechanism of rolling friction. I. The plastic range. K. R. ELDREDGE AND D. TABOR. *Proc. Roy. Soc. A*, **229**, 181–98 (*April* 21, 1955).

A study of the friction and surface damage produced when a hard steel sphere rolls between flat parallel surfaces of a softer metal. When rolling first starts, even at small loads, there is marked plastic flow of the surfaces and a grooved track is formed. The resistance to rolling is primarily due to the plastic displacement of metal ahead of the ball and may be calculated in terms of the area of the grooved track and the yield pressure of the metal. In the first traversal the ball is supported on the front half of the circle of contact. On rolling back along this track there is no such support for the ball unless it sinks further into the surfaces. This leads to an increase in the width of the groove and further displacement of metal. With successive traversals there is a slow increase in groove width and a gradual decrease in rolling resistance. For metals such as tin which do not work-harden appreciably these changes may be explained quantitatively on the assumption that the area supporting the load remains substantially the same throughout the series of traversals. The rolling resistance throughout this stage is due primarily to plastic displacement and depends little on lubrication. A study of the deformation produced during rolling shows that the centre of the grooved track is very heavily sheared in the direction of rolling, and with repeated traversals this may lead to rapid fatigue of the metal. Here again lubricants have little effect on the rate of fatiguing. As rolling proceeds there is an increase in track width, a slight change in track curvature and, in general, appreciable work-hardening of material within and around the track. As a result of these factors an equilibrium stage is gradually reached (if fatigue failure does not occur first) at which the whole of the load is borne by the ellipse of contact formed by elastic deformation within the width of the existing track. No further appreciable increase in track width occurs, and the rolling friction remains substantially constant for repeated traversals of the track. The rolling friction at this stage is again scarcely affected by lubricants. A.

539.622

5005. The mechanism of rolling friction. II. The elastic range. D. TABOR. *Proc. Roy. Soc. A*, **229**, 198–220 (*April* 21, 1955).

Discusses the mechanism of rolling friction under conditions where the deformations involved are predominantly elastic. Experiments on the rolling of a metal cylinder over a rubber surface show that interfacial slip of the type described by Reynolds is minute and totally insufficient to account for the observed resistance to rolling. It is shown quantitatively that the rolling resistance under these conditions is due to elastic hysteresis losses in the rubber. This accounts for the ineffectiveness of lubricants in reducing the rolling friction. Similar results are obtained for hard spheres rolling on rubber surfaces. If, however, a sphere is rolled in a preformed rubber groove, interfacial slip between the ball and groove may occur since the central band on the ball measures out a larger circle than the bands at the edge of the groove. A simple quantitative theory of this effect is given. This type of slip, first described by Heathcote, is very marked when the groove is deep and of curvature very close to that of the ball; under these conditions a suitable lubricant can effect a considerable reduction in the rolling resistance. For shallower grooves the differential slip is reduced and the Heathcote contribution to the observed rolling resistance becomes trivial. These conclusions are applied to the rolling friction of a hard steel sphere in the equilibrium groove formed in the surface of a softer

metal. If the rolling friction is attributed to the Heathcote mechanism a coefficient of friction within the ellipse of contact of the order of $\mu = 1$ to 2 must be invoked even in the presence of the best boundary lubricants. This is impossibly high. If, on the other hand, the rolling friction is attributed to hysteresis losses, large loss factors, greater than 20%, must be invoked for example for copper surfaces. In order to resolve this difficulty a new experimental approach has been adopted in which a copper ball is rolled over an identical copper ball. Because of symmetry conditions at the region of contact both the Reynolds and the Heathcote type of slip are eliminated. The equilibrium rolling friction is found to be as high as that observed when a hard steel sphere rolls in a copper groove. It is concluded that interfacial slip contributes little to the rolling friction although it may play an important part in surface wear. Consequently, lubricants may reduce the amount of wear but have little effect on the rolling resistance. The greater part of this arises from elastic hysteresis losses within the metals themselves. A.

PHYSICAL CHEMISTRY 541

PHASE EQUILIBRIUM . CHEMICAL REACTIONS 541.11/.12

541.124

5006. A mechanical method for the activation of fast reactions. T. H. Bull and P. B. Moon. *Disc. Faraday Soc., No.* 17, 54–7 (1954).

By relatively simple mechanical means, pulsed beams of molecules moving with speeds up to about a kilometre per second can be obtained. Heavy atoms and molecules moving at such speeds carry energies of the order of 10 kcal/mole and may react with other molecules with which they collide. Preliminary experiments have been made on the formation of CsCl by the impact of CCl_4 on Cs. A.

541.124

5007. Shock waves in chemical kinetics. The rate of dissociation of molecular iodine. D. Britton, N. Davidson and G. Schott. *Disc. Faraday Soc., No.* 17, 58–68 (1954).

Inert gas $+ \sim 1\% I_2$ mixtures have been rapidly heated to temperatures of 1 060–1 860°K by passage of a shock wave and the rate of the dissociation reaction, $M + I_2 \underset{k_R}{\overset{k_D}{\rightleftharpoons}} M + I + I$, measured photoelectrically. The reaction times were of the order of 30–300 μsec. The experimental results for the rate constants for recombination are given by $\log_{10} k_R (\text{mole}^{-2} 1.^2 \text{sec}^{-1}) = 8{\cdot}87 - 1{\cdot}90 (\pm 0{\cdot}14) \log_{10} (T/1\,000)$ (argon); $\log_{10} k_R = 8{\cdot}85 - 1{\cdot}91 (\pm 0{\cdot}29) \log_{10} (T/1\,000)$, ($N_2$, assumed to be vibrationally unexcited); $\log_{10} k_R = 9{\cdot}01 - 1{\cdot}44 (\pm 0{\cdot}32) \log_{10} (T/1\,000)$, ($N_2$ assumed to be vibrationally exicted). Comparison of the average high-temperature results with those obtained at room temperature by flash photolysis confirms the negative temperature coefficient for k_R but suggests the relation, $k_R = A/T^{1{\cdot}5}$. The high-temperature values for k_D for argon fit the equation, $k_D = 1{\cdot}5 \times 10^7 T^{\frac{1}{2}} (U/RT)^{2{\cdot}8} \exp(-U/RT) \text{mole}^{-1} 1. \text{sec}^{-1}$, where U = molal energy of dissociation of I_2 at 0°K. The extinction coefficients of I_2 at 490 mμ and 436 mμ were measured as a function of temperature; as expected, the former decreased with temperature and the latter increased. The rate data do not reveal whether the nitrogen is vibrationally unexcited or excited during the time period of the experiments; the extinction coefficient data favour the former possibility. A.

541.124

5008. Relaxation techniques for fast reactions. A study of the dissociation of nitrogen tetroxide. S. H. Bauer and M. R. Gustavson. *Disc. Faraday Soc., No.* 17, 69–90 (1954).

Attention is called to the thermodynamic and kinetic features of those reactions which are "fast" and for which relaxation techniques must be used. The various methods which have been applied to the study of the nitrogen tetroxide dissociation are briefly discussed as examples of the variety of available devices. In the method here used, the gas was expanded relatively slowly and isentropically by making it flow through a properly shaped nozzle; then it was rapidly compressed (in an interval of several microseconds) in front of an obstacle set in the stream parallel to the flow lines. The observed difference between the original pressure and the stagnation pressure is shown to be directly proportional to the entropy gained in the latter non-equilibrium compression. Experimental details and data on CO_2 and N_2O_4 are given. A general relaxation theory is set up for systems which must be represented by several groups of degrees of freedom, wherein equilibrium exists within the groups but not among the groups. The rate of establishment of complete equilibrium is evaluated in terms of a spectrum of relaxation times, both for the case when the perturbation is impressed as a step function and when it is introduced as a specified function of the time. At the present stage of development, the data obtained with the above apparatus allow the direct evaluation of an average relaxation time; individual values can be estimated by a trial-and-error process. An effort is being made to develop an inversion scheme for deducing the spectrum. The average values found for CO_2 and N_2O_4 are compared with those reported by other investigators. An analysis of the errors inherent in this method is presented. A.

541.124

5009. The study of free radicals by mass spectrometry. F. P. Lossing, K. V. Ingold and I. H. S. Henderson. *Applied Mass Spectrometry Conference Report*, 102–11 [see Abstr. 5066 (1955)].

It is possible by the use of a mass spectrometer in conjunction with a reaction vessel for the study of reaction kinetics, to detect the presence of short-lived intermediates and radicals in a single experiment, and

thus an insight into the reaction mechanism can be obtained. Here such experiments are reported: methyl radicals were detected during thermal decomposition of a large number of compounds, which are tabulated. CH_3S, vinyl, ethyl, allyl, propyl, isopropyl, benzyl, phenyl, phenoxy and benzoyl radicals were also detected in various reactions. In some cases the rates of reactions involving radicals could be measured. Ionization potentials were found for methyl (9·95 eV), allyl (8·16 eV) and benzyl (7·73 eV). From these values bond dissociation energies could be calculated in some cases. A. J. TAYLOR

541.124

5010. The kinetics of coordinate bond formation. II. G. B. KISTIAKOWSKY AND R. WILLIAMS. *J. chem. Phys.*, **23**, *No.* 2, 334–8 (*Feb.*, 1955).

For Pt I, see Abstr. 3053 (1952). The technique of temperature pattern determination, shown previously to be suitable for the measurement of fast gaseous reactions, has been extended to reactions of boron trifluoride with ammonia, dimethylamine, *n*-butylamine, *t*-butylamine and pyridine. The bimolecular rate constants of the first two of these show pressure dependence; those of the other three, within experimental error, do not. A comparison with the previously obtained results on methylamine and trimethylamine demonstrates that the life-time of the "hot" quasi-molecules formed by the addition of boron trifluoride and an amine increases regularly with the number of vibrational degrees of freedom of the quasi-molecule. The rates of addition are all substantially smaller than the rate of recombination of methyl radicals. They increase by about a factor of thirty from that of ammonia to those of heavier amines, being then about 1/30 of the collisional frequency. This finding is not consistent with the supposition that steric requirements alone limit the rates of addition and the existence of a small activation energy is clearly suggested, although it could not be observed experimentally. To explain the present results, the activation energy must decrease from ammonia to heavier amines. Such a decrease is found to be consistent with the presently accepted views on the electronic structure of the boron—nitrogen bond. A.

541.124 : 536.46

5011. The sodium diffusion flame method for fast reactions. I. Theory of the experimental method. J. F. REED AND B. S. RABINOVITCH. *J. phys. Chem.*, **59**, *No.* 3, 261–6 (*March*, 1955).

A critical analysis of the diffusion flame method for sodium atom reactions has been made. When the streaming velocity is considered in the differential equation of continuity and the flow of sodium into the system used as a boundary condition, flame shapes are distorted from spherical and calculated rate constants lowered from those calculated in the conventional manner. Consideration of halide back-diffusion leads to an interpretation of the lower v/D limit which is determined by experimental variables and the reaction rate constant. Heller's lower limit is found to be a special case. Halide distribution in the flame is briefly discussed. A.

541.124.7

5012. An ultrasonic investigation of a chemical kinetics problem: the dissociation of magnesium sulfate. D. A. BIES. *J. chem. Phys.*, **23**, *No.* 3, 428–34 (*March*, 1955).

New equations for the excess sound absorption per wavelength and the relaxation frequency have been derived. These equations are derived on the assumption that a dissociation process of the type $(AB) \rightleftharpoons (A) + (B)$ is irreversibly perturbed by the sound field due to assumed pressure dependence of the equilibrium. These equations are applied to the problem of excess sound absorption in dilute magnesium sulphate solutions. By using mixtures of dioxane and water to vary the dielectric constant of the solvent the effect of varying the ion Coulombic interaction forces of the ions in solution has been studied experimentally. This work and the work of other investigators on the excess sound absorption in dilute magnesium sulphate solutions is explained quantitatively. The specific rates of dissociation and ion association for magnesium sulphate in solutions of water and water-dioxane have been determined. Good agreement is found between values of the mass action equilibrium constant determined by acoustic means and values determined by the usual conductivity method. The experimental activation energy of molecular dissociation is determined to be 6·5 kcal/mole while the activation energy of ion association is estimated to be 8·5 kcal/mole. A.

541.126 : 548.74

5013. Nucleation in silver azide: an investigation by electron microscopy and diffraction. J. SAWKILL. *Proc. Roy. Soc. A*, **229**, 135–42 (*April* 5, 1955).

The beam of an electron microscope has been used to decompose single crystals of silver azide into nitrogen and metallic silver. The decomposition was slow enough to allow electron-diffraction photographs and electron micrographs to be taken at various stages of the decomposition. From these observations it is possible to follow very closely the process of nucleation. The diffraction photographs show that two forms of silver result, one highly oriented and the other randomly oriented. The microscope identifies the two forms. The randomly oriented silver appears to separate at the boundaries of a substructure of the crystal. The highly oriented silver exists as discrete nuclei, of dimensions of the order $0{\cdot}1 \times 0{\cdot}1 \times 0{\cdot}05\,\mu$, probably formed near the surface of the silver azide crystal. The nuclei consist of normal metallic silver only at the end of the decomposition. There is no evidence for the formation in the early stages of a small speck of metallic silver which then grows. Rather, a nucleus is a region into which silver diffuses to build up a face-centred cubic lattice of parameter greater than that of normal silver, and which uses the silver positions in the silver azide lattice as the basis for this build-up. In the last stage a collapse to normal metallic silver takes place. During decomposition the size of a nucleus does not appear to change, but the density increases. A.

541.127

5014. Photoelectric methods for following fast gas-phase reactions. H. S. JOHNSTON. *Disc. Faraday Soc.*, *No.* 17, 14–21 (1954).

Several similar systems are described which, by photoelectric and oscilloscopic methods, directly

follow fast gas-phase reactions over a wide range of pressure and temperature. The guiding principle behind the development of these methods was that reaction should be followed at constant temperature and at constant volume, so that results may be compared directly with those obtained by regular means. The fact that a reaction is fast makes difficult the requirement of constant temperature for gases. For this and other reasons, rates successfully measured by these methods have had half-lives no shorter than 0·1 sec and usually from 0·1 to 1 or more sec. Oxides of nitrogen, ozone and fluorine are typical of the substances whose rates have been followed by these methods. A.

541.127

5015. A thermal method of investigating fast gas-phase reactions. I. The mercury photo-sensitized decomposition of ethylene. A. B. CALLEAR AND J. C. ROBB. *Disc. Faraday Soc., No.* 17, 21–31 (1954).

Describes a method of measuring rates of reactions which occur so quickly as to render inadequate any conventional experimental method based, for example, on pressure measurements. The mercury photo-sensitized decomposition of ethylene has been investigated by this method and shown to occur by a mechanism somewhat simpler than that which has been previously proposed. A.

541.127

5016. The temperature pattern method in the study of fast chemical reactions. D. GARVIN, V. P. GUINN AND G. B. KISTIAKOWSKY. *Disc. Faraday Soc., No.* 17, 32–9 (1954).

Polanyi's technique of spherically symmetric "highly dilute flames" has been modified for the study of those fast gaseous bimolecular reactions which are not accompanied by useful optical phenomena. The new method involves the measurement of the temperature pattern within and without the reaction zone under conditions of very small thermal gradients and preponderantly diffusional mass and heat transport. An idealized theory of such measurements is developed and it is shown that the chosen experimental arrangement satisfies reasonably well the theoretical requirements. Some of the results obtained with reactions between boron trifluoride and a series of amines are discussed and the limitations of the method are emphasized. Nonetheless, it should be of a rather wide usefulness in the studies of very fast gaseous reactions. A.

541.127

5017. The application of flash techniques to the study of fast reactions. R. G. W. NORRISH AND G. PORTER. *Disc. Faraday Soc., No.* 17, 40–6 (1954).

Three experimental difficulties arise in the study of rapid reactions. These are the necessity for rapid homogeneous initiation, the lack of isothermal conditions and the loss of sensitivity in methods of detection when the time available for measurement is reduced. Flash photolysis is particularly suitable for rapid initiation and flash spectroscopy reduces the limitations caused by the other two effects. Potentialities and limitations of these techniques are discussed and reference is made to possible methods of detection other than the usual photographic and photoelectric recording of electronic absorption spectra. A.

541.127

5018. Reactions of atomic oxygen with molecular oxygen. R. A. OGG, JR AND W. T. SUTPHEN. *Disc. Faraday Soc., No.* 17, 47–54 (1954).

Oxygen gas highly enriched in O^{18} isotope has been used for rate studies of the exchange reaction $O^{16}O^{16} + O^{18}O^{18} \rightleftharpoons 2O^{16}O^{18}$. The relative proportions were followed by mass spectrometer analysis. Added isotopically normal ozone is found to catalyse attainment of this equilibrium, the reaction being very rapid in comparison with O^{18} exchange between O_2 and O_3. This precludes the direct O atom transfer reaction between O_2 and O_3 as being appreciably involved. The only alternative appears to be the ultra-rapid exchange reactions exemplified by $O + OO^{18} \rightarrow OO + O^{18}$. Vagaries in the dissociation of ozone make a precise determination of the rate constant very difficult, but an activation energy of practically zero and a "normal" frequency factor somewhat less than 10^{12} mole^{-1} cm^3 sec^{-1} appear indicated. Some uses of the system as a reagent for detecting production of O atoms are discussed. The present study suggests that at low pressures the concentration of O atoms exceeds that corresponding to equilibrium with O_3 and O_2, an effect attributed to energy chains. A.

541.127

5019. Regeneration and recirculation of reactants in the rapid-flow apparatus. I. Design criteria. B. CHANCE. *Disc. Faraday Soc., No.* 17, 120–3 (1954).

An equation has been derived that assists in the optimal design of rapid-flow apparatuses employing spectrophotometric observation. This equation incorporates chemical, geometrical, optical and electronic factors, and is used to compute the performance of two rather different types of apparatus. The equation furthermore suggests improvements that are incorporated into the design of new flow apparatuses. These devices are described in detail. A.

541.127

5020. Regeneration and recirculation of reactants in the rapid-flow apparatus. II. Practical designs. B. CHANCE AND V. LEGALLAIS. *Disc. Faraday Soc., No.* 17, 123–8 (1954).

A method for increasing the performance of a rapid-flow apparatus for the study of labile intermediates 10- to 100-fold without expenditure of additional enzyme solution is described. Two apparatuses have been constructed, one for recording the spectra of labile intermediates, the other for measuring the kinetics of their formation, and examples of their performances are included. A.

541.127

5021. The application of photoelectric spectrophotometry to the constant flow method. K. DALZIEL. *Disc. Faraday Soc., No.* 17, 128–32 (1954).

The conditions under which accurate spectrophotometric analysis has been applied to the constant flow method are described, and the precision and validity of the method in the kinetic study of rapid reactions are discussed, with particular reference to the accuracy of the extinction measurements and the errors due to deviation from "mass" flow. A.

541.127

5022. A semi-automatic apparatus for the photometric measurement of the rates of fast reactions. E. F. Caldin and F. W. Trowse. *Disc. Faraday Soc., No.* 17, 133–7 (1954).

An apparatus for measuring the rates of fast reactions involving colour changes in solution is described. The apparatus is designed to allow accurate kinetic measurements over a range of temperature in any solvent. It gives rate constants reproducible and accurate to about ±2%; it can be used for reactions with times of half-change down to ½ msec, and the temperature can be adjusted to ±0·1°C between 0 and 50°C. Operation is semi-automatic and gives a complete photographic record of the run. A.

541.127

5023. Stopped-flow apparatus for the study of rapid reactions. Q. H. Gibson. *Disc. Faraday Soc., No.* 17, 137–9 (1954).

An apparatus is described for recording optical density changes in solutions. Light from a tungsten filament passes through interference filters (Barr and Stroud), through the solution under observation and on to a photomultiplier. The output from this is applied directly to a cathode-ray oscillograph and the trace photographed. The fluid driving system is manually operated and, using a flow-stopping device, allows flow rates up to 5 m/sec with a volume of 0·5 ml per trace. Recording takes place from 0·003 sec after mixing onwards, and changes in optical density are reproducible within about 1% of the total change measured. A.

541.127

5024. A quenching method for studying rapid reactions. B. R. W. Pinsent. *Disc. Faraday Soc., No.* 17, 140–1 (1954).

Quenching methods are commonly used to study the rate of slow reactions but have been used very little for the measurement of rapid reactions. However, when used in conjunction with very rapid mixing and a flow apparatus of the Hartridge-Roughton type, a quenching method can prove very useful, particularly for reactions of half-times of 50 msec to 1–2 sec. Reactions at this rate, while being too rapid to be measured by normal kinetic methods are yet too slow to be conveniently measured by the more common rapid-reaction techniques. A.

541.127

5025. The measurement of the rate of rapid reactions by a thermal method. L. Pearson, B. R. W. Pinsent and F. J. W. Roughton. *Disc. Faraday Soc., No.* 17, 141–5 (1954).

An apparatus is described for measuring the rate of fast reactions which have an appreciable heat of reaction. The reacting solutions are mixed and pass along an observation tube at a constant speed. Readings of the temperature are made with a thermocouple in several positions in the tube. The rate of reactions with half-times as low as 2 msec can be measured. The apparatus has been used for measuring the rate of reaction of carbon dioxide in solution with hydroxide ions and ammonia. A.

541.127

5026. The capacity flow method in chemical kinetics. K. G. Denbigh and F. M. Page. *Disc. Faraday Soc., No.* 17, 145–51 (1954).

The capacity flow method consists in the creation of a steady state of constant and uniform concentration in a well-stirred vessel operating continuously. The method is suitable for the investigation of reactions of half-period between 1 and 4000 sec and also for the study of transient intermediates at a stationary concentration. In complex reactions the capacity flow method has the advantage of mathematical simplicity. A.

541.127

5027. Developments in the thermal maximum method for reaction velocities in solution. R. P. Bell, V. Gold, J. Hilton and M. H. Rand. *Disc. Faraday Soc., No.* 17, 151–6 (1954).

Modifications have been introduced in the method previously described [Abstr. 3959 (1952)] which increase its accuracy and extend its applicability down to half-times of about 0·2 sec. A.

541.127

5028. Applicability of megacycle frequency oscillator circuits to reaction rate measurement. P. J. Elving. *Disc. Faraday Soc., No.* 17, 156–67 (1954).

The basis for the application is described, in particular where insulated cells are used, i.e. cells in which electrodes or other electrical connective devices are not in contact with the sample solution. The applicability to ionizable systems in aqueous solution is stressed. In such media, the use of a high-frequency oscillator permits rapid measurement of electrical conductance since point to point balancing of a bridge is unnecessary. In non-aqueous systems, megacycle oscillators can be used to follow both conductance and dielectric constant change. The general relation of high-frequency conductance and capacitance to the usual low-frequency conductance is indicated. The critical factors involved include oscillator type and frequency, cell design, and sample composition. The general limitation on the use of the technique is due to the fact that only one physical property of the system is being measured. The specific application of an oscillator circuit to follow the rapid alkaline hydrolysis of esters is described in some detail to illustrate the methodology involved in studying ionic reactions. A.

541.127

5029. The use of rotating and stationary electrodes for fast reactions. I. M. Kolthoff and W. L. Reynolds. *Disc. Faraday Soc., No.* 17, 167–73 (1954).

An experimental method is described which uses a rotated platinum wire electrode to determine concentration changes in a fast reaction. Limitations and possible ways to extend the range of applicability of this method are discussed. The rate constants for the reaction of aquo ferrous iron with *p*-menthane hydroperoxide, *tert.*-butyl hydroperoxide, and cumene hydroperoxide were found to be $1{\cdot}0\times10^{7}\exp(-7700/RT)$, $9{\cdot}35\times10^{7}\exp(-9220/RT)$, and $3{\cdot}1\times10^{8}\exp(-9940/RT)$ l. mole^{-1}. sec^{-1}, respectively. A.

541.127

5030. Studies of the triplet state in fluid solvents. G. Porter and M. W. Windsor. *Disc. Faraday Soc., No.* 17, 178–86 (1954).

By means of the flash photolysis technique, transient

absorption spectra, attributed to molecules in their triplet states, have been observed following photolysis of a large number of organic substances in fluid solvents. Half-lives investigated lie between 10^{-2} and 10^{-5} sec and the fractional conversion to the triplet state is high enough for the determination of absolute concentrations and extinction coefficients. The kinetics of decay of triplet anthracene have been studied in some detail. In hexane the decay is first-order with respect to triplet concentration and independent of the concentration of normal anthracene in the range 10^{-3} to 2×10^{-6} M. In the presence of dissolved oxygen a more rapid decay occurs and oxygen is removed. In the absence of oxygen, and in solvents with which the triplet molecules do not react, the rate constant is a function of solvent viscosity. The rate-determining process for this decay is attributed to an adiabatic crossing of potential energy surfaces, inhibited by viscous solvents. A.

541.127

5031. Rates of ion recombination in solution by a radio-frequency dispersion method. R. G. Pearson. *Disc. Faraday Soc., No.* 17, 187–93 (1954).

A method is outlined for determining the rates of the very rapid reactions involved in mobile ionic equilibria. The method depends on the relaxation of the second Wien effect in the presence of radio-frequency fields. Low field strengths can be used and power losses occur which, while small compared to ohmic power losses, should be readily measurable. Limitations of the method are discussed, the most serious being that it is likely that only rates of ion-pair formation can be measured, rather than rates of ions forming covalent molecules. A.

541.127

5032. Methods for investigation of ionic reactions in aqueous solutions with half-times as short as 10^{-9} sec. Application to neutralization and hydrolysis reactions. M. Eigen. *Disc. Faraday Soc., No.* 17, 194–205 (1954).

Three possible experimental methods for studying fast ionic reactions in aqueous solutions are described: (i) the sound absorption method, (ii) the electric impulse method using high field densities ("dissociation field effect"), (iii) the "temperature jump method." All three methods are based on measurements of the chemical relaxation of an electrolytic dissociation equilibrium effected by rapid variation of (i) pressure, (ii) electrical field density, and (iii) temperature. The results permit a mathematical treatment which gives information about the kinetics of extremely fast reactions. According to experimental results, bimolecular reactions in which protons and hydroxyl ions take part are characterized by extremely high rate constants of the order of 10^{10} to 10^{11} l/mole. sec, while reactions between other ions proceed substantially more slowly. The behaviour of H^+ and OH^- ions may be understood in connection with models for the anomalous mechanism of movement of these ions in water. In addition, the velocity of some dissociation reactions in aqueous solution has been measured. A.

541.127

5033. Applications of voltammetry at constant current in chemical kinetics. P. Delahay. *Disc. Faraday Soc., No.* 17, 205–15 (1954).

Various kinetic and catalytic processes in voltammetry at constant current are treated, and theoretical and experimental methods for the determination of rate constants are presented. The conditions under which the method can be applied are examined, and potentialities of the constant current method in chemical kinetics are compared with those of polarography. A.

541.127

5034. Study of ultrarapid reactions by nuclear magnetic resonance spectra. R. A. Ogg, Jr. *Disc. Faraday Soc., No.* 17, 215–20 (1954).

Proton magnetic resonance has been studied in pure liquid ammonia, and in solutions of water, KNH_2, $NaNH_2$, NH_4Br and H_3NBF_3 in this solvent. Intensively dried NH_3 shows a well-defined spin-spin interaction triplet. In sufficient concentration all of the additives reduce the resonance to a narrow singlet. With $NaNH_2$ the systematic broadening of the triplet lines and ultimate narrowing has been followed by increasing concentration. An approximate figure of $4{\cdot}6\times10^{11}$ mole^{-3}. cm^3. sec^{-1} is found for the proton transfer reaction rate constant $NH_3 + NH_2^- \rightarrow NH_2^- NH_3$. It is inferred that this ultrarapid reaction must have a very small activation energy. A.

541.127 : 535.417

5035. A photoelectric recording interferometer. G. M. Burnett, P. J. Deas and H. W. Melville. *Disc. Faraday Soc., No.* 17, 173–8 (1954).

The study of the non-stationary state of radical reactions enables the velocity coefficients of the elementary reactions to be determined with some degree of precision. The method depends on having apparatus sensitive to small changes in percentage reaction and having a sufficiently fast time response. A number of methods have now been devised to satisfy these requirements but further improvements are desirable so that the method can be applied to systems other than polymerization. One such method involved the construction of a photoelectric recording Jamin-type interferometer [Abstr. 6834 (1951)]. Certain difficulties were encountered in the original design; the present paper describes an improved version. A.

541.127 : 578

5036. Rapid reactions in biology. F. J. W. Roughton. *Disc. Faraday Soc., No.* 17, 116–20 (1954).

A brief account is given of the biological background and historical development of the Hartridge-Roughton rapid reaction velocity method. Current applications of the technique to three problems of biological interest are described: (i) the determination of the average time spent by the blood in contact with the air in the lungs of man, (ii) the determination of the velocity constants of the four successive reactions of carbon monoxide with haemoglobin, (iii) the possible estimation of the velocity constant of combination of enzyme with substrate, from kinetic measurements during a very brief induction period after mixture of enzyme and substrate. A.

541.128 : 541.135

5037. Mechanism of the catalytic activation of molecular hydrogen by metal ions. J. HALPERN AND E. PETERS. Letter in *J. chem. Phys.*, **23**, *No.* 3, 605 (*March*, 1955).

The catalytic activation of molecular H_2 by means of cupric acetate in aq. solution is not specific to the reduction of Cr_2O_7'', but other oxidants such as Ce'''' and IO_3' can also be reduced homogeneously by this method. All these reactions proceed by the same mechanism, the rate-controlling step involving cupric acetate and H_2 only. This catalytic property is also shown by other Cu'' salts including the completely dissociated cupric perchlorate, although, at 100°, the catalytic effect of the perchlorate is about 120 times lower than that of the undissociated acetate and similar complexes. The catalytic activity is specific to the salts of certain metals. Of the other common divalent metals only Hg'' possesses similar activity. The kinetic results suggest that a complex is formed between H_2 and a metal ion or monomeric metal complex. In this process the H_2 becomes activated probably by the transfer of an electron from the H_2 to the metal ion. A. J. MEE

ELECTROCHEMISTRY 541.13

541.132

5038. Ionization in solutions of nitrogen dioxide in nitric acid from optical-absorbance measurements. S. LYNN, D. M. MASON AND W. H. CORCORAN. *J. phys. Chem.*, **59**, *No.* 3, 238–40 (*March*, 1955).

Values of the optical absorbance of solutions of nitrogen dioxide in nitric acid were measured at 0° and 1 atmosphere using light at a wavelength of 425 mμ. The data obtained were applied in a study of the ionization occurring in the solutions. The numerical solution of simultaneous equations based on equilibrium expressions indicates that in nitric acid solutions containing less than 1 formal weight per cent nitrogen dioxide the nitrogen dioxide is about 70% ionized into nitrosonium (NO^+) ions, whereas the nitric acid is about 5% ionized into nitronium (NO_2^+) ions. Although the uncertainty is high, the order of magnitude of these values is correct. A.

541.133.1

5039. Transference numbers of electrolytes under pressure. F. T. WALL AND S. J. GILL. *J. phys. Chem.*, **59**, *No.* 3, 278–83 (*March*, 1955).

A method has been developed for determining transference numbers of simple electrolytes under high pressures. In this method, which is an adaptation of the conventional moving boundary technique, the movement of the ions is followed by resistance measurements. The results obtained by this procedure at 1 atm. are in good agreement with literature values for 0·1 N KCl, NaCl and HCl. At 1 000 bars, a slight increase was observed for the cation transference number of 0·1 N HCl. A 2% decrease in cation transference number was observed for 0·1 N KCl and even larger decrease was noted for the cation of 0·1 N NaCl. Cadmium chloride was employed as the "following" solution, and the transference number of Cd^{++}, calculated from the Kohlrausch regulating function and conductivity data, likewise decreased with increase in pressure. A.

541.133.1 : 539.217 : 539.155.2

5040. Isotope transport and self-diffusion in metals. A. KLEMM. *Z. Naturforsch.*, **9a**, *No.* 12, 1031–5 (*Dec.*, 1954) In German.

The electrolytic transport of the light isotope to the anode in molten Hg and Ga is explained on the basis of the assumption that in metals there are mobile and relatively immobile ionic states. The former interact strongly with the electrons and are thus transported to the anode. The light isotope wanders more quickly to the anode than the heavier one since for the former the ratio of mobile to immobile states is greater than the ratio for the latter. W. GOOD

541.135

5041. The problem of the rate of electrolytic deposition of metals. A. SHELUDKO AND M. TODOROVA. *Izv. Bulg. Akad. Nauk.*, **3**, 61–76 (1952; publ. 1954). In Bulgarian. Summaries (2 pp.) in Russian and German.

The relation between the nuclei formed electrolytically during a certain period under the influence of an applied voltage consisting of a different metal, and the voltage applied, was experimentally investigated, the metal deposited being mercury from a concentrated solution of $HgNO_3$ and the support a polished Pt microelectrode. The anode was a large mercury surface. The voltage applied had pulse character. Up to a certain duration of the pulses the relation between number of nuclei and time was linear. The nuclei formed were allowed to grow until they became visible under a microscope (magnification ×100). It was possible to keep the voltage applied so low that the nuclei formed could grow larger, but that no further nucleation could take place. After every test the microelectrode was cleaned anodically at about 4 V. The dispersion of the results necessitated the carrying out of a large number of tests from which average values were used to obtain the relation between number of nuclei and voltage (Z, η) which showed log Z to be a linear function of $1/\eta^2$. This agrees very well with theoretical expressions derived from fluctuation theory, also enabling the empirical constants of these expressions to be determined. However, not only have the various constants to be determined from quantities not easy to determine experimentally, but the order of magnitude of the work of nucleation determined theoretically is much higher than the value experimentally found. This leads to the interpretation that the nuclei actually formed were deposited on "activated" points of the Pt surface, which reduces the required work of nucleation. Further consideration of the results gained showed that even the area of the "activated" Pt surface can be determined from the constants of the empirical equations. It is thus found that the active surface area is only 10^{-8} of the area of the Pt microelectrode. This represents a confirmation of the correctness of the results and fully agrees with experimental findings of other authors. B. F. KRAUS

541.135

5042. The behaviour of the reference substance during a Nernst electrolysis and a new interpretation of the experiments of Washburn. L. H. COLLET. Letter in *J. Phys. Radium*, **16**, *No.* 2, 159–61 (*Feb.*, 1955) In French.

Equations are derived which give the absolute

transport numbers respectively of the cation and anion of an electrolyte in terms directly accessible to experiment. Recalculation of the results of Washburn [*J. Amer. Chem. Soc.*, **31**, 322 (1909)] indicate water flow to the cathode and acceleration of the anion in solutions of HCl, LiCl, NaCl and KCl. W. GOOD

541.135.5

5043. Influence of electrode material on oxygen overvoltage: a theoretical analysis. P. RÜETSCHI AND P. DELAHAY. *J. chem. Phys.*, **23**, *No.* 3, 556–60 (*March*, 1955).

Variations of overvoltage for oxygen evolution from one metal to another primarily result from variations in the energy of the bond M—OH. The overvoltage decreases approximately in a linear manner with increasing bond energy. This relationship is verified experimentally for Ag, Au, Cd, Co, Cu, Fe, Ni, Pb, Pd and Pt, for electrolysis in one N potassium hydroxide at 1 amp cm^{-2}; the experimental data are those reported by Hickling and Hill. Bond energies for M—OH are calculated by three different thermodynamic cycles involving, respectively, the standard heat contents of the hydroxide, the oxide, and spectroscopic data for molecules MO. Variations of the energy of the bond M—OH, as the electrode is oxidized to a higher valence, also account for sudden breaks in plots of overvoltage against logarithm of current density. Finally, there is essentially no correlation between the oxygen overvoltage for different metals and the corresponding work functions. A.

541.135.5

5044. Strain potentials. R. S. DUDLEY, R. ELLIOTT, W. H. MCFADDEN AND L. W. SHEMILT. Letter in *J. chem. Phys.*, **23**, *No.* 3, 585 (*March*, 1955).

Potential-time relationships between stressed and unstressed high-purity annealed Cu wires immersed in $CuSO_4$ and in $CuCl_2$ solutions were measured. The major effect of the application of a stress is transient and due to the distortion or disruption of the surface film of oxide. In $CuSO_4$ solutions the effect is concentration-dependent, in $CuCl_2$ solutions from 0·005 to 0·10 N it is concentration-independent. W. GOOD

541.135.5 : 537.311.33

Experiments on the interface between germanium and an electrolyte. *See Abstr.* 4650

PHOTOCHEMISTRY . RADIATION CHEMISTRY 541.14/.15

541.14

5045. Decomposition of ammonia photosensitized by mercury $6(^3P_1)$ atoms. C. C. MCDONALD AND H. E. GUNNING. *J. chem. Phys.*, **23**, *No.* 3, 532–41 (*March*, 1955).

An investigation has been made of the mercury—$6(^3P_1)$—photosensitized decomposition of ammonia at room temperature, under both flow and static conditions. Nitrogen and hydrogen were produced in the static experiments; hydrazine was an additional product in the flow experiments. The quantum yield of ammonia decomposition in the flow experiments did not depend on the flow rate but increased in an exponential manner, as the reaction pressure was decreased, from a value of 0·09 at 650 mm toward unity at very low pressures. The quantum yield in the static experiments at high ammonia pressures and at a low extent of reaction was about the same as in the flow experiments at comparable pressures. The static quantum yield decreased when the extent of reaction was increased, when the ammonia pressure was decreased, or when hydrogen was added to the reaction. The percentage of the decomposed ammonia which was recovered as hydrazine increased from zero at low flow rates to 95% at high flow rates. At a fixed flow rate, the hydrazine-to-nitrogen ratio increased, as the ammonia pressure was increased, from zero to a maximum value which was pressure independent at higher pressures. The hydrazine-to-nitrogen ratio increased as the incident intensity of 2 537 Å radiation was decreased. When ethylene was added to the flow experiments the hydrazine-to-nitrogen ratio was markedly increased. However, when platinum wire was introduced into the irradiated zone, the reaction was found to be unchanged. A mechanism is suggested which appears to give the best representation of the results. A.

541.15

5046. Emission of ultraviolet radiation from gas mixtures under the action of α-particles. S. LORMEAU-LOUSTAU. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 7, 768–70 (*Feb.* 14, 1955) In French.

The intensity of the radiation emitted by gas mixtures under α-particle irradiation is not always the sum of the intensities which would be emitted by each constituent alone, e.g. in mixtures $N_2 + O_2$ or $N_2 + H_2$ in various proportions, although the emission from $H_2 + O_2$ is additive. This loss of photons is interpreted in terms of chemical action between the components of the mixtures [see Abstr. 2449 (1949)].

C. B. ALLSOPP

541.15

5047. Electrical and chemical effects of β-radiation in polystyrene. P. Y. FENG AND J. W. KENNEDY. *J. Amer. Chem. Soc.*, **77**, *No.* 4, 847–51 (*Feb.* 20, 1955).

Electric conductivity of polystyrene, polyethylene and Teflon under β-irradiation has been studied by investigation of the potentials produced by the passage of β-rays through the dielectrics. A potential of 60 kV has been produced in a single stage and 88 kV in two stages. The potentials agree reasonably well with values calculated from the assumptions that the dielectric conductivity is proportional to the concentration of radiation-produced ions and that these ions disappear by bimolecular reaction. Irradiation of polystyrene by β-particles is found to cause degradation if air is present but to cause further polymerization if air is excluded. Bombardment of polystyrene in a helium atmosphere by deuterons caused extensive cross-linkage. The data obtained in studies of the radiation chemical effects in polystyrene show that the rate of polymerization depends on the square root of the radiation intensity. In the presence of air the rate of degradation varies with something between the square root and the first power of the radiation intensity. A.

541.15

5048. The effect of variations in source intensity on the alpha induced decomposition of ammonia. B. P. BURTT AND T. BAURER. *J. chem. Phys.*, **23**, *No.* 3, 466–70 (*March*, 1955).

The ion yield in the α-induced decomposition of gaseous ammonia is found to increase slightly with the irradiation intensity, both in the presence and absence of electric fields. This is true for ammonia pressures of both 20 cm and 50 cm, at room temperature. Even a weak electric field increases the ion yield at 50 cm pressure. There is no evidence at 20 or 50 cm pressure of initiation of the reaction by ion recombination. Possible mechanisms are suggested. A.

541.15

5049. The radiation chemistry of nitrite ion in aqueous solution. H. A. SCHWARZ AND A. O. ALLEN. *J. Amer. Chem. Soc.*, **77**, *No.* 5, 1324–30 (*March* 5, 1955).

When de-aerated solutions of KNO_2 at their natural pH are irradiated with γ- or X-rays, the main initial reaction is a formation of hydrogen and hydrogen peroxide. As peroxide builds up, a radiation-induced reaction between nitrite and peroxide sets in, which results in the formation of nitrate. This reaction is slower the higher the nitrite concentration. The kinetics of the nitrite-peroxide reaction were studied in detail by the irradiation of synthetic mixtures, and the results were satisfactorily explained by a free radical mechanism. The main feature of the mechanism is a competition between H_2O_2 and NO_2^- for reaction with H atoms generated in the water. The yield for H-atom formation is found to be 2·4 per 100 eV. The initial yield of peroxide in the pure nitrite solutions is greater than the yield of hydrogen, and decreases with increasing nitrite concentration, at concentrations below 0·002 M. The effect of nitrite on the initial peroxide yield is qualitatively similar to the effect of bromide reported by Sworski. In nitrite solutions containing oxygen, an immediate nitrite oxidation occurs on irradiation, with a yield which increases with increasing ratio of the concentration of nitrite to that of oxygen. A.

541.15 : 538.222

Paramagnetic species in gamma-irradiated ice. *See Abstr.* 4798

DISPERSIONS . COLLOIDS . ADSORPTION
541.18

541.182.2/3 : 537.24

5050. The statistical electrification of aerosols by ionic diffusion. R. GUNN. *J. Colloid Sci.*, **10**, *No.* 1, 107–19 (*Feb.*, 1955).

A quantitative investigation of the diffusion of atmospheric ions on to spherical particles is reported. Special emphasis is given to random charging processes. The analysis shows that in typical cases about half of the particles are positively charged and the other half negatively charged. Nearly every particle carries at least one electronic charge and some twenty or more. Expressions are developed for the statistical distribution of the fractional number of droplets in relation to their charge. When particle collisions are infrequent, the average free charge of the positive and negative fractions depends only on the square root of the radius and the mean thermal energy of each droplet. It is shown that an equipartition is established between the electrical potential energy of each drop and its thermal kinetic energy. Typical particle electrification somewhat increases the coagulation rate normally attributable to diffusion alone. Systematic droplet electrification of a selected sign is superimposed on this random charging if the positive and negative light ion conductivities of the environment have appreciably different values. The calculated distribution and average charge magnitude agree with those observed on silica dust and new measurements on cloud particles. A.

541.182.3 : 532.787

5051. On the utilization of supersaturated solution for the detection and counting of silver iodide nuclei. R. MONTMORY. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 7, 801–2 (*Feb.* 14, 1955) In French.

The aerosol or a preparation of the particles from it are projected on to the surface of a thin film of supersaturated silver iodide in triethylene glycol; silver iodide particles or other particles with the same crystal symmetry cause precipitates to form and hence such nuclei can be detected and counted. J. M. HOUGH

541.182.43 : 537.226.1

5052. The electrical conductivity and permittivity of mixtures, with special reference to emulsions of water in fuel oil. C. A. R. PEARCE. *Brit. J. appl. Phys.*, **6**, *No.* 4, 113–20 (*April*, 1955).

The electrical characteristics of a mixture of two substances are dependent only in part on the electrical characteristics of the individual phases. In addition to the volume ratio of the components of the mixture other factors such as particle shape and distribution have important effects on the characteristics. In this connection an emulsion formed of a liquid with a high conductivity in one of low conductivity is free from the complications of many practical mixtures. The droplets are spheres and the system approaches the case which has been attacked theoretically with the greatest success. The characteristics of water in fuel oil emulsions have been studied both directly and indirectly by means of an electrolytic analogue. The work has drawn attention to the importance of the size distribution of the dispersed phase and has confirmed the theoretical treatments of Wiener and Bruggeman at the same time emphasizing the limitations of their formulae. This has given the work a value in applications outside the narrow field of the specialized emulsions in which it originated. A.

541.183

5053. Quantitative treatment of the electrostatic influences in the adsorption of charged particles. H. NETTER AND H.-D. OHLENBUSCH. Note in *Naturwissenschaften*, **41**, *No.* 24, 570–1 (1954) In German.

A relation between interfacial potential, surface tension, concentration and pH is derived theoretically for the adsorption of higher fatty acids at a liquid-liquid interface. W. GOOD

541.183

5054. The time of adsorption and the time of oscillation. S. KRUYER. *Proc. K. Ned. Akad. Wetensch. B*, **58**, *No.* 1, 73–7 (1955).

Expressions are given, based on statistical mechanics, for the time τ of adsorption, for both mobile and localized adsorption. For mobile adsorption, $\tau = \tau_0 \exp(-\Delta H_0/RT)$ where ΔH_0 = heat of adsorption at 0°K, and τ_0 is composed of partition functions. At 300°K $\tau_0 \simeq 10^{-13}$ sec if the two translations in the surface, and the rotations, are not seriously hindered; but if any of these translations or rotations are lost (and so if adsorption is localized), $\tau_0 \ll 10^{-13}$ sec. For physical adsorption one can usually calculate the approx. adsorption per unit area, Γ, as $\Gamma = \{p/(2\pi mkT)^{\frac{1}{2}}\} \times 10^{-13} \times \exp(-\Delta H/RT)$ where ΔH = heat of adsorption, p = pressure, m, k, R, T have their usual meanings. S. J. GREGG

541.183

5055. Contribution to the study of adsorption and desorption on the surfaces of liquids. L. TER MINASSIAN-SARAGA. *J. Chim. phys.*, **52**, *No.* 1, 80–94 (*Jan.*, 1955) In French.

A brief general account of the history of the study of surface films on water is given, followed by a description of techniques for measuring the surface pressure of insoluble films and the surface tension of soluble films. Measurements are described leading to the isotherm of a film of lauric acid on 0·01 M HCl at 20° (particular attention being paid to thermostatting) from the gaseous state (I) to the liquid expanded (II). Equations of state are given for both I and II. The retention of the hydrocarbon solvent by the film has been studied experimentally.

S. J. GREGG

541.183

5056. Investigation of the physically adsorbed state by means of dielectric measurements. E. W. CHANNEN AND R. MCINTOSH. *Canad. J. Chem.*, **33**, *No.* 2, 172–83 (*Feb.*, 1955).

Dielectric data obtained for a variety of adsorbates on porous silica gel and on non-porous rutile are summarized. Four methods of computing the polarizabilities or dielectric constants of the adsorbed matter are outlined and applied using the primary experimental data of capacitance change and volume adsorbed. All four methods contain somewhat arbitrary assumptions and at best are semi-empirical. None predicts values of the electrical constants of the adsorbed species which appear reasonable in all cases. It is concluded that an interpretation of the phenomena revealed by the primary data is not possible until improved methods of computing the polarizability of adsorbed material are developed. A.

541.183

5057. Use of interpolation theory in the analysis of gas adsorption isotherms. I. Theory. J. M. HONIG AND P. C. ROSENBLOOM. *Canad. J. Chem.*, **33**, *No.* 2, 193–202 (*Feb.*, 1955).

The theory presented in this paper permits the determination of extremal bounds for a given adsorbate-adsorbent system within which the adsorption isotherms must fall if certain assumptions pertaining to the nature of the adsorption process are applicable. The use of interpolation theory in estimating lower and upper bounds on physical quantities of interest in adsorption theory is also discussed. A.

541.183

5058. The determination of pore size distribution and surface area from adsorption isotherms. E. M. VOIGT AND R. H. TOMLINSON. *Canad. J. Chem.*, **33**, *No.* 2, 215–31 (*Feb.*, 1955).

Theoretical isotherms have been developed which when compared to experimental isotherms showing hysteresis, allow the calculation of pore size, pore size distribution, and surface area of the sorbent. Interpretation of some experimental isotherms obtained with porous vycor glass shows that this system can best be represented by the "ink bottle" pore model with a Gaussian distribution of pore sizes. The mean pore radius of the porous glass is about two-thirds of the Kelvin radius, and the surface area greater than that obtained from the B.E.T. theory. The Kelvin radius is interpreted as a weighted average, but the B.E.T. surface area appears more fundamentally different. A.

541.183

5059. Reversibility in physical adsorption. E. L. PACE, K. S. DENNIS, S. A. GREENE AND E. L. HERIC. *Canad. J. Chem.*, **33**, *No.* 2, 245–50 (*Feb.*, 1955).

The question of reversibility and equilibrium is considered in relation to the physical adsorption of gases on finely divided solid surfaces. Conclusions are drawn from calorimetric measurements of (1) adsorption isotherms, (2) integral, differential, and isosteric heats of adsorption, and (3) heat capacity of the adsorbed phase for surface coverages of the order of a monolayer or less. In line with the preceding, results are presented and discussed for calorimetric studies involving (1) heats of adsorption and heat capacities of methane adsorbed on rutile between 80 and 140°K, (2) heats of adsorption of argon on rutile between 60 and 90°K, and (3) the zero point entropy of krypton adsorbed on rutile at a coverage of about 0·57 of the monolayer capacity. A.

541.183 : 532.51

5060. Thermodynamic considerations of surface regions, adsorbate pressures, adsorbate mobility, and surface tension. E. A. FLOOD AND M. HUBER. *Canad. J. Chem.*, **33**, *No.* 2, 203–14 (*Feb.*, 1955).

The flow of water through the micropore system of activated carbon has been described in previous papers as a hydrodynamic flow of liquid water under high pressure gradients due to surface forces. It is shown below that these high pressures are probably real and that the temperature coefficient of the flow rate is closely related to the temperature coefficient of the viscosity of liquid water. Surface tension is discussed. A.

541.183 : 537.226.1.08

5061. An apparatus for the measurement of dielectric constants of adsorbed gases at frequencies up to 100 Mc./sec. M. H. WALDMAN AND R. MCINTOSH. *Canad. J. Chem.*, **33**, *No.* 2, 268–78 (*Feb.*, 1955).

The design of an apparatus suitable for the measurement of dielectric constants at frequencies up to 106 Mc/s is shown. The apparatus was used to measure changes in capacitance with volume adsorbed

for the system sulphur dioxide-rutile at about 3·5°C and for frequencies of 13, 36 and 106 Mc/s. The results failed to reveal any dispersion due to the adsorbed matter in this frequency range. The dielectric behaviour observed is the same, within experimental error of a few per cent, as that found by Channen and McIntosh for the same system at 3·7 Mc/s. A.

541.183 : 548.5

5062. The growth of crystalline layers on foreign surfaces. J. H. Singleton and G. D. Halsey, Jr. *Canad. J. Chem.*, **33**, *No.* 2, 184–92 (*Feb.*, 1955).

When the bulk phase of an adsorbent is solid, it has been shown that adsorption often proceeds only to a finite limit as the pressure reaches saturation. A theory is developed for this finite limit, in terms of the excess forces at the surface and the incompatibility of the crystal lattices of the adsorbent and adsorbate. It is applied to the stepwise adsorption of krypton on graphitized carbon black. An extrapolation formula applicable to smooth isotherms at high coverages is developed and shown to be analogous to the Harkins–Jura equation. It is applied to argon adsorbed on carbon black, on xenon preadsorbed on carbon black, on silver iodide, and on anatase. The energies obtained are compared with a theoretical estimate based on the Kirkwood–Müller equation. A theory for calculating isotherms on preadsorbed layers is developed and compared with the data for argon on xenon. A.

541.183.022

5063. New technique for compressing surface films. I. H. Sher and J. D. Chanley. *Rev. sci. Instrum.*, **26**, *No.* 3, 266–8 (*March*, 1955).

A new method of applying continuous mechanical pressure to monomolecular films is presented. The advantages of the method include: simple and inexpensive apparatus, ability to produce continuously any desired pressure without adjustments, freedom from piston-oil contaminations and streaks, ease and speed of cleaning surface for next film, and full spreading of successive films. A.

541.183.25 : 537.226.3

Study of water adsorption by the dielectric method. *See Abstr.* 4628

CHEMICAL ANALYSIS 543/545

545.7

5064. Continuous analysis of ortho-parahydrogen mixtures. D. H. Weitzel and L. E. White. *Rev. sci. Instrum.*, **26**, *No.* 3, 290–2 (*March*, 1955).

A Gow–Mac thermal conductivity unit has been utilized in the construction of a continuous flow analyser for ortho-parahydrogen mixtures. No pump or vacuum system is required. The unit possesses adequate sensitivity for operation at room temperature, thus eliminating the need for low temperature baths. Parameters which influence reproducibility have been investigated and simple techniques for their control are suggested. A.

545.824

5065. *K*-capture spectroscopy. Iron-55 X-ray absorption determination of sulfur in hydrocarbons. H. K. Hughes and J. W. Wilczewski. *Analyt. Chem.*, **26**, *No.* 12, 1889–93 (*Dec.*, 1954).

This new X-ray absorption method, suitable for many types of chemical analyses, utilizes a small quantity of radioactive iron-55 instead of a conventional high voltage tube as the source of radiation. The equipment is compact and simple to operate, and is now in use in a petroleum refinery laboratory for the determination of sulphur in the range 0·05 to 2·7%. The method is faster than any other now in use and the equipment cost is only slightly higher than for the bomb method. Other advantages are the elimination of frequent restandardization of the "zero" beam, improved safety, and a reduction in equipment warm-up time. A.

545.827

5066. Applied mass spectrometry. *London: The Institute of Petroleum* (1954) 333 *pp.*

Report of a conference organized by the Mass Spectrometry Panel of the Institute of Petroleum and held in London 29–31 October, 1953. Twenty-seven papers. For abstracts of some of these, see Abstr. 4759, 5009, 5067–8. Among other papers included are: *Recent developments in high resolution mass spectrography*, H. Ewald (223–29). *Non-electronic computing methods in mass spectrometric analysis*, M. Jones (258–68). *Application of digital computing methods to mass spectrometry analysis*, G. P. Barnard and L. Fox (269–93).

545.827

5067. The analysis of heavy water by mass spectrometric methods. E. Roth. *Applied Mass Spectrometry Conference Report*, 81–90 [see Abstr. 5066 (1955)].

As the ratio of atomic weights of the H isotopes is exceptionally high, special techniques for analysis are necessary. Three courses can be followed: the sample may be analysed mass-spectrometrically directly, or give up hydrogen to another compound, which can be analysed more easily. If this new compound is hydrogen, a special procedure may be followed. This last method is used most frequently. The memory effect which is caused by the exchange of H and D atoms between samples, the large mass difference between these atoms, and the possibility of a change in isotopic composition during the reaction process are difficulties in the experimental determination. The design of suitable apparatus and the preparation of samples are discussed. The mass-spectroscopic method of analysis of heavy water is usually very sensitive, though elaborate. For specific problems and routine analysis in the higher concentration range there is a trend towards the use of other methods. A. J. TAYLOR

545.827

5068. Mass spectrometry and molecular structure. C. A. McDowell. *Applied Mass Spectrometry Conference Report*, 129–153 [see Abstr. 5066 (1955)].

The mass spectrum of most compounds is unique. The numbers of fragments into which a molecule is

ionized depends on the energy of the ionizing electrons. The complexity of such a spectrum therefore depends on this also, as all ionizations which occur originate in Franck–Condon transitions. Apart from ions, smaller molecules, radicals and atoms are formed. Thus in most cases a characteristic set of ions, etc. is formed. Only isomeric butenes give main ions, the intensities of which are similar, so that it is difficult to distinguish between them. Here the mass spectra of H_2, N_2, O_2, HCN, NH_3 and CH_4 are discussed in detail, and conclusions are drawn as to which reactions take place and which ions and radicals are formed during the process. A. J. TAYLOR

545.827

5069. Trace-quantity analysis: neutron activation applied to potassium-mineral dating. A. Moljk, R. W. P. Drever and S. C. Curran. *Nucleonics*, **13**, *No.* 2, 44–6 (*Feb.*, 1955).

A^{40} formed in a KCl sample as a result of the decay of K^{40} was estimated by neutron irradiation and measurement of the 1·8 hr A^{41}. The gas was released from the KCl, by fusing the latter, or dissolving it in water, under vacuum, and collected in a quartz container for irradiation. Possible contamination by atmospheric argon would be indicated by A^{37} radiation. Somewhat low estimates of the age of the mineral samples obtained in this method are attributed to inefficient collection of the gas due to adsorption on the surface of the quartz vessels. L. R. SHEPHERD

545.827

5070. Lead analysis by the isotopic dilution method with RaD as carrier. H. v. Buttlar. *Naturwissenschaften*, **42**, *No.* 4, 90–1 (1955) In German.

The advantages and disadvantages attached to the use of RaD as dilution isotope in the estimation of lead and in the isotopic analysis of lead by mass spectrometric and interferometric methods are discussed. W. GOOD

545.827

5071. Radiochemical determination of cerium in fission. L. E. Glendenin, K. F. Flynn, R. F. Buchanan and E. P. Steinberg. *Analyt. Chem.*, **27**, *No.* 1, 59–60 (*Jan.*, 1955).

The work reported was undertaken to develop a simple and rapid radiochemical procedure for the determination of cerium activity produced in nuclear fission. A method was developed based on solvent extraction of cerium (IV) with methyl isobutyl ketone. Good separation from the large number of elements encountered in fission product sources is afforded by the extraction procedure as well as a considerable saving in time and effort over the ceric iodate precipitation method in previous use. Further applications of the new procedure are the preparation of carrier-free radioactive cerium and activation analysis for small amounts of cerium. A.

545.827

5072. High frequency induction furnace in the determination of radiocarbon. A. M. Gaudin and H. E. Bergna. *Analyt. Chem.*, **27**, *No.* 3, 467–8 (*March*, 1955).

Assay of materials labelled with carbon-14 commonly involves their oxidation to carbon dioxide, which is then measured directly by a Geiger counter or in a carbon dioxide ionization chamber. Alternatively, the material may be converted to a solid, such as barium carbonate, before radioassay. The use of high frequency induction heating in an oxygen atmosphere provides a fast, reliable method of oxidizing radioactive carbon to carbon dioxide, which can then be determined in the usual way. The method has been successfully applied to the combustion of radiocarbon in mixtures of labelled lauric acid and quartz and in radioactive solutions. The radioactive carbon dioxide has been assayed with internal Geiger counters to prove the reliability of the combustion method. A.

545.83 : 551.508

5073. Detection of certain ions in 10^{-10}- to 10^{-15}-gram particles. B. K. Seely. *Analyt. Chem.* **27**, *No.* 1, 93–5 (*Jan.*, 1955).

The modified spot-test methods described in this paper are extensions of a technique previously described by the author for the identification of micron and submicron chloride particles. The technique depended upon microscopic observation of chemical reactions in the surface of a gelatin medium sensitized with a mercurous salt. This paper discusses in detail similar procedures for the identification of copper, cobalt, nickel, ferrous and ferric ions, sodium and potassium, as well as iodides and carbonates in particulate matter. The sensitivity of the method permits the identification of masses four to six orders of magnitude smaller than is possible by conventional spot-test procedures as reported in the literature. The methods have been used primarily for the study of atmospheric particles but they may be applied to other fields of study. A.

CRYSTALLOGRAPHY 548

548.1 : 537.228.1 : 539.31

5074. Study of crystalline elasticity and piezoelectricity. I. Disagreement between experiment and the theory of Voigt. Y. Le Corre. *Bull. Soc. Franç Minéral. Crist.*, **77**, No. 10–12, 1363–92 (*Oct.–Dec.*, 1954) In French.

It has been shown by Laval that an atomic theory of elasticity requires 45 elastic coefficients and not 21 as does Voigt's theory. The results predicted by these two theories are compared in the case of ADP and of quartz. Experiments are described which support Laval's theory. In the case of ADP the velocity of propagation of an elastic wave along the fourfold axis is found to differ from that along the twofold axis, and in the case of quartz it is found that the wave can be polarized along its threefold axis. W. BARDSLEY

548.1 : 537.228.1 : 539.31

5075. Study of crystalline elasticity and piezoelectricity. II. Tensorial theory of elasticity and of piezoelectricity. Y. Le Corre. *Bull. Soc. Franç. Minéral. Crist.*, **77**, *No.* 10–12, 1393–409 (*Oct.–Dec.*, 1954) In French.

The tensors of strain and stress are not symmetrical. The elastic, piezoelectric and dielectric properties of a triclinic crystal can be represented by a symmetrical matrix of 12 lines and 12 columns giving 78 independent coefficients: 45 elastic coefficients, 27 piezoelectric coefficients and 6 dielectric coefficients. The dynamic elasticity is treated with the help of the 36 coefficients. One cannot in general deduce the 21 coefficients of Voigt. W. BARDSLEY

548.5

5076. Layer growth of artificial graphite. T. Tsuzuku and T. Komoda. Note in *J. Phys. Soc. Japan*, **10**, *No.* 1, 81–2 (*Jan.*, 1955).

Pyramidal layer growth observed on single crystals of artificial graphite is illustrated and discussed briefly in terms of dislocations. Step heights vary from 150 to 350 Å. S. WEINTROUB

548.5

5077. Cage zone refining. P. H. Brace, A. W. Cochardt and G. Comenetz. Letter in *Rev. sci. Instrum.*, **26**, *No.* 3, 303 (*March*, 1955).

Vertical zone melting by induction heating of a bar of polygonal cross-section. The edges of the bar act as cooling fins which are not melted, and confine the liquid zone. This method does not allow single crystals to be grown but may be used for bars of bigger diameter than those of Abstr. 5195 (1953). Refining of Ti bars is described. J. FRANKS

548.5 : 541.183

The growth of crystalline layers on foreign surfaces. *See Abstr.* 5062

548.51 : 541.183

5078. Influence of adsorption on the equilibrium form and the work of nucleation of crystals. G. Bliznakov. *Izv. Bulg. Akad. Nauk.*, **3**, 23–41 (1952; publ. 1954). In Bulgarian. Summaries (2 pp.) in Russian and German.

The problem is treated from a formal-thermodynamical view-point and based on the consideration of the influence of the adsorption on the vapour pressure of a small crystallite. It is found that two crystallites of the same size may have different vapour pressures according to the quantity of capillary-active substance adsorbed. If the adsorption on a crystal, which may differ for every crystallographic face, is considered, the Gibbs–Wulf condition yields the equilibrium form. A condition for the invariance of the equilibrium form is then easily derived, yielding a further criterion for deciding whether or not a face belongs to the equilibrium form. Relations are also derived for surface energy, supersaturation and free surface, respectively. It is then shown how to consider the influence of adsorption on the work of nucleation of a quadratic or cubic nucleus. Lastly, the relation between the method used and the thermodynamic-statistical method of Stransky and Kaishev is discussed, and the fact that the latter must yield the same results is stressed. B. F. KRAUS

548.55

5079. Formation and identification of thallium single crystals. K. D. Alexopoulos. *Acta cryst.*, **8**, *Pt* 4, 235–6 (*April*, 1955).

A crucible is described in which a metal can be cooled from the melt while subjected to a strong temperature gradient. By this method single crystals of thallium were obtained when the gradient exceeded 20°c/cm. A simple X-ray method is described for determining whether the sample is a single crystal and for finding the hexagonal axis. In some samples a body-centred cubic phase was observed with a lattice constant 3% smaller than the value for the high-temperature phase. A.

ATOMIC AND X-RAY CRYSTALLOGRAPHY 548.7

548.7

5080. Classical nonlinear lattice statics of distorted crystal structures. E. Fues and H. Stumpf. *Z. Naturforsch.*, **10a**, *No.* 2, 136–45 (*Feb.*, 1955) In German.

A method is given for the calculation of the equilibrium arrangement of the atoms of a crystal on the basis of central two-body forces. The method also yields the restoring forces of all the atoms after local displacement, and takes full account of non-linearity. As a simple example, the displacements near an interstitial atom in the close-packed lattice are found, using interatomic potentials of the form $A/r^3-B/r^{13}$. The power of the second term was varied and its effect is given in graphical form.

W. M. LOMER

548.7

5081. A new treatment of anharmonicity in lattice thermodynamics. I. D. J. Hooton. *Phil. Mag.*, **46**, 422–32 (*April*, 1955).

Born has given a method by which the anharmonic vibrational motion of the atoms in a crystal can be approximated in terms of an adapted set of harmonic oscillations, these differing from the usual modes of vibration of harmonic lattice dynamics; this method is here redeveloped from another standpoint and extended to give explicit results. The thermodynamical formulae of the anharmonic crystal can be given a simple form: they consist of the customary formulae for a set of harmonic oscillators, but now expressed in terms of new frequencies defined essentially from the quadratic and quartic terms in an expansion of the potential energy, plus correction terms which express the difference between the actual anharmonic motion and the harmonic approximation. For small anharmonicity the formulae reduce to those of the usual perturbation procedure (allowance for thermal expansion) with some extensions, but they also give a solution in the case of strong anharmonicity. This latter solution will later be used in a discussion of solid helium. A.

548.7

5082. A new treatment of anharmonicity in lattice thermodynamics. II. D. J. Hooton. *Phil. Mag.*, **46**, 433–43 (*April*, 1955).

The thermodynamical formulae of Pt I are worked

out with the help of an adaptation of Debye's continuum approximation; in particular, the specific heat at constant volume is put into a form suitable for numerical calculation. This formula contains, however, a factor which expresses the (possibly strong) volume dependence of the relation between the new frequency spectrum and that of the customary lattice dynamics; the factor appears in addition to the Debye characteristic temperature θ and must be estimated in any particular application—for example, in the following consideration of solid helium it will be approximated from a linear chain model. The meaning of a Debye characteristic temperature in the anharmonic theory is discussed, and the place of an empirical Debye temperature, determined by fitting specific heat measurements to a theoretical specific heat formula, is also considered. A discussion of this fitted Debye temperature (due to Domb and Salter) is adapted to the anharmonic theory in order to give later a correct application to solid helium. A.

548.7

5083. On the motion of slow electrons in polar materials. S. Zienau. *Rep. Brit. Elect. Res. Assoc., Rep. L/T299*, 21 *pp.* (1953).

The technique of canonical transformation is applied to various problems connected with the behaviour of a slow electron in an ionic crystal. The connection with previous and closely related work by Gurari [Abstr. 4476 (1953)] is discussed. A.

548.7

5084. On a study of the interaction of electrons with a phonon field by the method of intermediate coupling. S. V. Tyablikov. *Zh. éksper. teor. Fiz.*, **25**, *No.* 6(12), 688–97 (1953) In Russian.

The effect of the interaction on the character of the energy spectrum of the electrons is studied for the case of ionic crystals, using a variational method appropriate to the case of intermediate coupling strengths. The Hamiltonian used is that of Abstr. 1249 (1953). The ground-state energy and effective mass are calculated for 2 assumptions about the Fourier transform $\chi(\nu)$ of the wave-function $\phi(r)$, viz. $\chi(\nu) = 1$ and $\chi(\nu) = \exp(-\alpha^2\nu^2)$. [Compare Lee and Pines, Abstr. 1248 (1953) and C. Gurari, Abstr. 4476 (1953).] The results are compared with the weak- and strong-coupling approximations. From an analysis of the numerical values of relevant parameters for some eleven ionic crystals it is concluded that in Cu_2O and PbS the coupling could be considered weak, but in the remaining cases neither the weak- nor the strong-coupling limit appears to be realized.

W. J. Swiatecki

548.7

5085. Persistent internal polarization. H. Kallmann and B. Rosenberg. *Phys. Rev.*, **97**, *No.* 6, 1596–610 (*March* 15, 1955).

Studies are reported on persistent internal polarization effects. This polarization can be produced, particularly in photoconductive, fluorescent substances of high dark resistance, by the action of various kinds of radiation in the presence of a d.c. electric field. It has been found that such polarizations, of more than 10000 volts/cm, will persist for many days if kept in the dark after field removal. A material so polarized is in many ways a photosensitive electret. Among the substances tested, a [Zn : Cd]S phosphor and anthracene were used most extensively. Measurements are reported on the effect of ultraviolet, visible and infrared light, γ- and β-rays on the production and removal of polarization. The increase of polarization with time is initially rapid and then shows saturation. It is almost a logarithmic function of the exciting radiation intensity, and a linear function of the polarizing voltage over a wide range. It is found that the equilibrium values of polarization are essentially determined by the applied voltage, and one parameter specific to the substance. Data are given on the long-time storage of polarization. It is shown that this polarization is due to a partial separation by the applied field of free mobile charges produced by the radiation inside the material and their localization in traps. It is not a charge injection-ejection phenomenon at the electrodes since it occurs just as well in samples insulated from the electrodes. In powders at least, the polarization is distributed throughout the entire sample and is not a charge accumulation near the surfaces. A correlation is established between these phenomena and the mechanism assumed for these substances to explain photoconductivity and fluorescence. A phenomenological model is presented which quantitatively describes many of the results of these experiments. This polarization effect provides a new method to detect and study energy storage in crystals. A.

548.7

5086. Generation of electron traps by plastic flow in alkali halides. M. Ueta and W. Känzig. *Phys. Rev.*, **97**, *No.* 6, 1591–5 (*March* 15, 1955).

Vacancy clusters, generated by moving dislocations, act as effective electron traps and change the photographic properties of the alkali halides considerably. This has been investigated by using additively coloured KCl and electrolytically coloured NaCl. Electrons were released from the *F*-centres by irradiation of *F*-light. In a plastically deformed crystal these electrons are immediately trapped by vacancy clusters and have not much chance to return to a negative ion vacancy. Therefore, the *F*-band bleaches much faster than in the case of undeformed crystals. Measurements of the bleaching rates permit an estimation of the number of traps generated by plastic flow. About 10^{17} traps per cm^3 are formed by a plastic strain of 10%. The nature of the traps depends upon the time which has passed after cold work. In the case of KCl, irradiation of *F*-light during plastic deformation gives rise to a pronounced enhancement of the *M*-band. Filling of the traps 48 hours after cold working results in the formation of a very broad band, centred near 800 mμ. The generation of *F'*-centres and the thermal conversion of *F'*-centres into *F*-centres are also strongly affected by the presence of these traps. A.

548.7

5087. Thermal formation of *F*-centres in silver halide crystals. P. V. Meĭklyar and R. S. Shimanskiĭ. *Zh. éksper. teor. Fiz.*, **27**, *No.* 2(8), 156–61 (1954) In Russian.

Reports measurements of the increase in optical density of silver bromide crystals on warming. The

number of *F*-centres produced thermally in various crystals at temperatures from room to 400°c is computed by assuming an oscillator strength of unity. The activation energy of the process is deduced to be ~0·2 eV. J. M. RADCLIFFE

548.7

5088. Mechanism of colouring of alkali halide crystals by X-rays. N. P. KALABUKOV. *Zh. éksper. teor. Fiz.*, **27**, *No.* 3(9), 347–50 (1954) In Russian.

Effects on absorption spectra of crystals coloured by X-rays of re-irradiating after decoloration. The absorption coefficient increases by about 60%. Measurements of irradiated and then decoloured crystals show that the electronic conductivity is greater than that of the untreated crystals. The connection of the phenomena with dislocations is affirmed. It is confirmed that in the process of irradiation there are produced new vacancies both of halogen and metal ions. J. EWLES

548.7

5089. Color centers in smoky quartz. A. J. COHEN. Letter in *J. chem. Phys.*, **23**, *No.* 3, 589–90 (*March*, 1955).

From a survey of results it is held that the absorption spectra of *F*-centres in fused silica and in α-quartz vary in position with the specific impurities present. Opposition is made to conclusions by Arnold supporting Niira's theory that band shifts are due to differences in Si–Si distances in α-quartz compared with fused silica. G. F. J. GARLICK

548.7

5090. Comment on "Color centers in smoky quartz." G. W. ARNOLD, JR. Letter in *J. chem. Phys.*, **23**, *No.* 3, 590–1 (*March*, 1955).

See preceding abstract. Experimental evidence from various sources is cited for ascribing absorption bands and shifts to structural defects rather than impurities in quartz and silica. G. F. J. GARLICK

548.7

5091. Radiation induced colour centres in fused quartz. M. LEVY AND J. H. O. VARLEY. *Proc. Phys. Soc.* [*London*] *B*, **68**, *Pt* 4, 223–33 (*April*, 1955).

Samples of fused quartz ("Vitreosil") have been irradiated by pile, γ- or X-rays and three absorption bands are produced with maxima at 2·3 eV, 4·1 eV and approximately 5·6 eV. It is suggested that the 2·3 eV band is due to sodium borate impurities in the glass. All three bands can be bleached either optically or thermally or, more rapidly, by a combination of both processes. An empirical law describing the thermal bleaching rate of the 2·3 eV band over a large range of n is $dn/dt = -Ae^{bn}$ where n is number of colour centres per cm^3 at time t; A, b are constants. Bleaching of the 2·3 eV and 4·1 eV bands can also be brought about by large doses of pile irradiation. This is attributed to vacancies caused by atomic displacements combining with electron traps to produce new centres. These latter are assumed to give an absorption outside the range of observation in these experiments, viz. 6·2 eV to 1·2 eV. A.

548.73/.74

X-ray and electron investigation of materials. *See also under* "Structure of solids." Decimal classification 539.26/.27.

548.732

5092. Fourfold refraction of X-rays through the ideal crystal lattice. G. BORRMANN. Note in *Naturwissenschaften*, **42**, *No.* 3, 67–8 (1955) In German.

Von Laue's theory [Abstr. 9162 (1952)] is used to show that, in general, four rays travel through a crystal set at the Bragg reflecting position to the incident X-ray beam. A. R. STOKES

548.732

5093. The absorption of interfering X-rays along their path in an ideal crystal lattice. G. BORRMANN AND H. WAGNER. Note in *Naturwissenschaften*, **42**, *No.* 3, 68 (1955) In German.

See preceding abstract. The variation of absorption with direction, near the Bragg reflecting position, is considered. A. R. STOKES

548.732

5094. The anomalous X-ray transmission through a crystal on both sides of the *K* absorption edge of an element in the crystal. G. BROGREN AND C. NORDLING. *Ark. Fys.*, **9**, *Paper* 22, 349–51 (1955).

Measurements of reflected and transmitted intensity have been carried out using zinc blende crystals, with wavelengths above and below the critical *K*-absorption edge of zinc. Qualitative agreement with theory is obtained; no more can be expected since the crystals have mosaic structure. A. R. STOKES

548.733

5095. A high-temperature X-ray goniometer. R. G. BUTTERS AND J. G. PARR. *Canad. J. Technol.*, **33**, *No.* 2, 117–21 (*March*, 1955).

A unit is described which, used in conjunction with a Philips high-angle X-ray diffraction goniometer, allows spectrometer plots to be made up to a temperature of 1 100°c. A.

548.734

5096. Improvement of roentgenometric methods of determining lattice defects of the third type in polycrystalline and powdered materials. A. KOCHANOVSKÁ. *Czech. J. Phys.*, **4**, *No.* 3, 290–9 (*Sept.*, 1954) In Russian.

A method is proposed, respecting the effects of microabsorption and primary extinction, which does not require the comparison with samples guaranteed to be free of faults. The method is based on the validity of an equation derived by Wilchinski for the integral intensity of the diffraction lines of non-ideal powder samples. The essence of the method is the measurement of the integral intensity of three suitably selected diffraction lines of the sample, in which the angle of incidence of the primary beam is equal to the Bragg angle θ corresponding to the given line. From the ratios of the integral intensities determined for the three lines it is possible to evaluate the sum of the magnitudes characterizing the faults of the third type and thermal faults $B_P + B_T$, as well as the magnitude T giving the size of the coherent lattice domains. A detailed analysis for tungsten is given, utilizing the characteristic radiation of molybdenum, cobalt and chromium. From the analysis, it follows that the greatest sensitivity of the method shifts with decreasing wavelength of the X-rays utilized to larger values of T. A.

548.734

5097. On line width determinations with bent crystal spectrometers. G. BROGREN. *Ark. Fys.*, **9**, *Paper* 17, 287–92 (1955).

The theory of the instrumental broadening of spectral lines is considered, but it is concluded that it is at present impossible to construct a formula for the broadening that takes account of all factors.

A. R. STOKES

548.734

5098. An X-ray goniometer with visual observation and its applications to the determination of crystal orientation. R. BODE AND R. MOCK. *Z. Naturforsch.*, **10a**, *No.* 2, 161–5 (*Feb.*, 1955) In German.

X-ray reflections are observed on a fluorescent screen, and the directions of the crystal axes are obtained directly with the help of a Wulff's net.

A. R. STOKES

548.734

5099. The stereograph: an apparatus for the rapid determination of the orientation of crystals from their Laue diagrams. H.-J. LATIÈRE. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 11, 1237–8 (*March* 14, 1955) In French.

A simple device is described, based on the principle of Schiebold and Saachs [*Zeitschrift für Kristallographie*, **63**, 34 (1926)], for producing pole figures directly from Laue diagrams. A. R. STOKES

548.735

5100. The calculation of the Lorentz-polarization factor $1/LP$ and its application to the retigraph. R. GAY. *Bull. Soc. Franç. Minéral. Crist.*, **77**, *No.* 10–12, 1330–6 (*Oct.–Dec.*, 1954) In French.

The formula is obtained in terms of the Bragg angle, the latitude of the intersection of the layer plane with the sphere of reflection, and the angle between the incident beam and the axis of rotation of the crystal. It is more convenient for chart construction than Buerger's equivalent formula [Buerger, M. J., *Proc. Nat. Acad. Sci. U.S.A.*, **26**, 637 (1940)]. A. R. STOKES

548.735

5101. Determining lattice defects of the third type and the size of coherent lattice domains in powdered tungsten. A. KOCHANOVSKÁ. *Czech. J. Phys.*, **4**, *No.* 4, 463–71 (*Nov.*, 1954) In Russian. Summary (1 p.) in English.

See Abstr. 8791 (1954). Measurements were made on three samples: the initial crushed tungsten, the same dry-ground for 96 hours and the same ground for 96 hours in an organic liquid medium. Sizes of coherent lattice domains were $<0{\cdot}5\mu$ for the first sample and about 2μ for both crushed samples, when molybdenum radiation was used: cobalt radiation gave larger values. The results are discussed from the point of view of sinterability of the samples.

A. R. STOKES

548.735

5102. With what precision does one need the Madelung constant of a crystal such as rocksalt? O. EMERSLEBEN. *Z. phys. Chem.* [*Leipzig*] **204**, *No.* 1–2, 43–55 (*Feb.*, 1955) In German.

It is concluded that for the purpose of comparing theoretical lattice energies with experimental data, there is no virtue in calculating the Madelung constant with an accuracy greater than about ½%. A. R. STOKES

548.735

5103. Statistics of complex functions: application to crystallography. F. BERTAUT. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 9, 938–40 (*Feb.* 28, 1955) In French.

A distribution function for complex amplitudes is obtained, which, it is suggested, may be useful for finding probable values of phase angles. A. R. STOKES

548.735

5104. On the treatment of unobserved reflexions in the least-squares adjustment of crystal structures. W. C. HAMILTON. Note in *Acta cryst.*, **8**, *Pt* 3, 185–6 (*March*, 1955).

It is recommended that the mean and the variance of the intensity of an unobserved reflection be taken as those values given by the probability theory of intensity distributions [see Abstr. 6171 (1950)] for space groups $P1$ and $P\bar{1}$. A. R. STOKES

548.735

5105. Applications of the difference-Patterson technique in structure analysis. G. KARTHA AND G. N. RAMACHANDRAN. *Acta cryst.*, **8**, *Pt* 4, 195–9 (*April*, 1955).

The difference-Patterson diagram, obtained by performing a Patterson synthesis with the differences in the intensities of two isomorphous crystals, is very useful for structure analysis, as it contains only peaks at positions corresponding to vectors joining replaceable atoms with other atoms. Methods are described whereby the structure can be deduced from this diagram. All centrosymmetric structures can be solved and among the non-centrosymmetric groups a duplication by an artificial centre of symmetry occurs only in eleven space groups, for general positions of replaceable atom. The method is shown to work with the phthalocyanines and with the isomorphous pair, barium chlorate and barium bromate. A.

548.736 : 545.824

5106. Standard X-ray diffraction powder patterns. IV. Data for 42 inorganic substances. H. E. SWANSON, R. K. FUYAT AND G. M. UGRINIC. *Circ. Nat. Bur. Stand.*, *No.* 539, 75 *pp.* (1955).

For Pt III, see Abstr. 3282 (1955). The patterns are presented in revision of the 95 corresponding patterns in the A.S.T.M. card file, together with a few not represented there. A.

548.736.1

5107. X-ray diffraction study of four reinforcing carbon blacks. L. ALEXANDER AND S. R. DARIN. Letter in *J. chem. Phys.*, **23**, *No.* 3, 594–5 (*March*, 1955).

Franklin's curve-fitting method [Abstr. 3521 (1950)] was used to obtain mean thicknesses and layer dimensions; these are tabulated. A. R. STOKES

548.736.1

5108. The X-ray anomalous reflexions from diamond. J. A. HOERNI AND W. A. WOOSTER. *Acta cryst.*, **8**, *Pt* 4, 187–94 (*April*, 1955).

The anomalous X-ray reflections from diamond have been investigated quantitatively using a photographic method. This investigation is restricted to

the anomalies which correspond in reciprocal spaces to "spikes" passing through certain reciprocal-lattice points, parallel to ⟨100⟩. It is found that the scattering density varies along the spikes according to the inverse 2·2 power of the distance from the associated reciprocal-lattice point. The "spike magnitude" defined in the text is proportional to the scattering density of the spike at unit distance from the reciprocal-lattice point divided by the square of the corresponding structure amplitude. It is found that for spikes parallel to [100], the spike magnitudes only depend on the index h of the reciprocal-lattice points. Their relative values are <5, 100, 75, 5 and 30 for $h = 0$, 1, 2, 3 and 4 respectively. Similar relations exist between the spikes parallel to [010] and [001], and the indices k and l. A theory to explain some of these results is advanced, based on the assumption that diamond has a domain texture and that each domain has a special atomic property associated with one of the three directions [100], [010], [001]. If the unique axis of a given domain is [100] then any one lattice plane parallel to (100) is populated by atoms of identical scattering power. The scattering power of the atoms in the various lattice planes varies in a random manner from one plane to another. A consequence of this theory is that not all of the carbon atoms in diamond are tetrahedrally symmetric. A.

548.736.1 : 539.13

Intermolecular forces and the crystal structures of the rare gases. *See Abstr.* 4832

548.736.3

5109. Al–Th intermetallic compounds. I. P. B. Braun and J. H. N. van Vucht. Note in *Acta cryst.*, **8**, *Pt* 2, 117–18 (*Feb.*, 1955).

548.736.3

5110. Al–Th intermetallic compounds. II. P. B. Braun and J. H. N. van Vucht. Note in *Acta cryst.*, **8**, *Pt* 4, 246 (*April*, 1955).

548.736.3

5111. X-ray measurements of pile-irradiated LiF. D. T. Keating. Letter in *Phys. Rev.*, **97**, *No.* 3, 832–4 (*Feb.* 1, 1955).

X-ray diffraction photographs of two single crystals of LiF irradiated in the Argonne pile with exposures of $2{\cdot}1\times10^{17}$ and $7{\cdot}5\times10^{17}$ nvt show small barely significant lattice expansions and no marked changes in the intensities but pronounced strain-broadening of the X-ray reflections. It is concluded that large regions of the crystals are in uniform compression or expansion and that imperfections collect in patches along certain (00l) planes. J. THEWLIS

548.736.3

5112. Brillouin zones of some intermetallic compounds. P. J. Black. *Phil. Mag.*, **46**, 401–9 (*April*, 1955).

Data on Brillouin zones for nine aluminium-rich compounds of iron have been obtained by X-ray analysis. For binary compounds and a ternary compound with nickel, the data can be correlated by assuming a reasonable electron absorption by iron, in agreement with previous results for alloys of cobalt and nickel. For ternary compounds containing copper and silicon, such correlation is not possible as the absorption required is obviously too high. Similar difficulties are encountered with some manganese compounds. It is suggested that the presence of a set of very strong X-ray reflections at nearly the same spacings is not a sufficient criterion for classifying these complex phases as electron compounds. A.

548.736.4

5113. Texture of crystals. II. NH_4Cl, $NaClO_3$ and alum. V. M. Padmanabhan. *J. Indian Inst. Sci. A*, **37**, *No.* 1, 23–6 (*Jan.*, 1955).

For Pt I, see Abstr. 9781 (1954). Using the method of internal reflection, the texture of ammonium alum, ammonium chloride and sodium chlorate was examined. Ammonium chloride was found to be mosaic, while ammonium alum and sodium chlorate were highly perfect. A.

547.736.5

5114. The crystal structure of tetrammine copper sulphate $Cu(NH_3)_4SO_4 . H_2O$. M. Simerská. *Czech. J. Phys.*, **4**, *No.* 3, 277–89 (*Sept.*, 1954).

The orthorhombic unit cell with dimensions $a = 12{\cdot}12$, $b = 10{\cdot}66$, $c = 7{\cdot}07$ Å contains four molecules of $Cu(NH_3)_4SO_4 . H_2O$, the space group is Pbnm (D_{2h}^{16}). The atomic co-ordinates were determined from the projections of the Patterson function and the electron density on to the (001) and (010) planes. The complex cation $Cu(NH_3)_4^{++}$ is approximately planar, the groups of NH_3 are linked by covalent bonds to the central Cu atom. The average distance of the groups of NH_3, which are approximately at the corners of a square surrounding the central Cu atom, is 2·90 Å, the distance Cu–NH_3, corresponding to the covalent bond, is 2·05 Å. A.

548.736.6

5115. On the structure of amethyst and its genesis in nature. C. V. Raman and A. Jayaraman. *Proc. Indian Acad. Sci. A*, **40**, *No.* 6, 221–9 (*Dec.*, 1954).

Amethyst is diamagnetic, its susceptibility being not measurably different from that of colourless quartz. The optical characters indicate only monoclinic symmetry, of which the diad axis coincides with one of the three electric axes of the associated quartz. An immediate explanation of why three colour sectors usually appear in amethystine quartz is thus forthcoming. The nature of the modifications in structure which alter trigonal to monoclinic symmetry is indicated. A study of an extensive collection of material indicates that the change of structure occurs during the growth of the crystal from material containing ferric impurities and is consequential on the progressive elimination of these impurities which are finally deposited as a dome of discrete particles on the boundary between the amethyst and the colourless quartz. A.

548.74

5116. High-temperature electron diffraction camera. B. Ya. Pines and A. I. Bublik. *Zh. tekh. Fiz.*, **24**, *No.* 6, 1139–45 (1954) In Russian.

A horizontal-type electron diffraction camera is described, for investigation of reflection and transmission specimens at elevated temperatures. The electron beam is focused electrostatically. It is shown that finely crystalline metal films may be transformed into almost single-crystal films by heating to just below the melting point. This technique may be useful in the preparation of single crystals of materials

of unknown structure for electron diffraction structure analysis. Diffraction patterns from unsupported liquid films of Bi and Sn are described. A short discussion is presented on the depression of melting point of unsupported metal films [Abstr. 3372 (1954)] and the "three layer film" which is the equilibrium state occurring over a certain interval of time during the supercooling of thin unsupported metal films [*Zh. tekh. Fiz.*, **22**, *No.* 12, 1985 (1952)]. J. A. SPINK

548.74

5117. Lattice constant measurements with electron beams on thin silver layers. V. HAUK AND A. KRINGS. Note in *Naturwissenschaften*, **42**, *No.* 3, 68–9 (1955) In German.

Compares electron diffraction with X-ray diffraction measurements on evaporated silver layers. For specimens of large grain size the agreement between the two sets of measurements is within 0·1%, but with a small grain size the electron diffraction value for the lattice constant depends on the actual grain size and on the reflections used. J. THEWLIS

548.74

5118. Fourier syntheses of electron-diffraction data. H. VIERVOLL. Letter in *Acta cryst.*, **8**, *Pt* 1, 56–7 (*Jan.*, 1955).

Discusses how the equations used in Fourier syntheses from electron diffraction investigations on crystals, which refer to the potential distribution of the crystals, may be transformed to equations referring to total charge distribution and nuclear charge distribution respectively. Radial distribution functions are also considered. J. THEWLIS

548.74

5119. The transition structure of nickel. G. I. FINCH, K. P. SINHA AND A. GOSWAMI. Letter in *J. appl. Phys.*, **26**, *No.* 2, 250–1 (*Feb.*, 1955).

Electron diffraction patterns from thin Ni films deposited on various substrates at temperatures between 300 and 340°C show a body-centred phase. After annealing at 400°C only the normal face-centred pattern is seen. It is suggested that this may be connected with the thermal anomalies near, but not accounted for, by the Curie point. W. M. LOMER

548.74

5120. Electron diffraction determination of lattice parameters of polycrystalline specimens giving broad diffraction peaks. I. Discussion of technique and analysis of errors. G. G. LIBOWITZ AND S. H. BAUER. *J. phys. Chem.*, **59**, *No.* 3, 209–14 (*March*, 1955).

The various errors which arise in the measurement of lattice parameters of compounds giving broad electron diffraction peaks have been considered. These were found to be (1) the shifting of diffraction peaks by the sharply sloping background, (2) visual difficulty in locating the true centre (maximum density) of a peak, (3) overlap of the tails of adjacent peaks and (4) spottiness of the diffraction rings. The magnitudes of these errors, and methods of correcting them are discussed. It was found that the use of a rotating sector was especially advantageous in such cases. A technique of preparing powder samples for electron diffraction studies of compounds containing impurities is given. A.

548.74

5121. Electron diffraction determination of lattice parameters of polycrystalline specimens giving broad diffraction peaks. II. A study of nickel oxide. G. G. LIBOWITZ AND S. H. BAUER. *J. phys. Chem.*, **59**, *No.* 3, 214–17 (*March*, 1955).

The lattice parameters of powdered samples of nickel oxide containing varying amounts of lithium oxide were determined. With increasing Ni^{+3} content, the lattice parameters decrease, and for the same samples the values as determined by electron diffraction agree with those determined by X-ray back reflection methods to within 0·002 Å. The crystallite size a determined by X-rays and electron diffraction have been compared, and an estimate of the inner potential of NiO was obtained from the measured relative broadening of the (200) and (111), (220) reflections. Conditions which must be met to permit detection of differences between surface and bulk lattice parameters are analysed. A.

548.74

5122. Electron diffraction pattern of mica of various thicknesses. T. HIBI. Letter in *Nature* [*London*] **175**, 475–6 (*March* 12, 1955).

The periodic variation of pattern with thickness of sample is tentatively explained in terms of parallel crystal layers, each successive layer being rotated at an angle of about 10°. R. REED

548.74 : 541.126

Nucleation in silver azide: an investigation by electron microscopy and diffraction. *See Abstr.* 5013

548.74

5123. Neutron diffraction by metallic erbium. W. C. KOEHLER AND E. O. WOLLAN. Letter in *Phys. Rev.*, **97**, *No.* 4, 1177–8 (*Feb.* 15, 1955).

The examination was carried out between room temperature and 4·2°K. At room temperature the neutron diffraction results are characteristic of a paramagnetic material and at 4·2°K they are characteristic of a ferromagnetic substance. Between 35°K and 80°K additional coherent reflections are observed which are suggestive of an antiferromagnetic structure. J. THEWLIS

GEOPHYSICS 55

550.341

5124. Effect of the earth's curvature on Love waves. N. JOBERT. *Ann. Geophys.*, **11**, *No.* 1, 1–48 (1955) In French.

A sudden displacement is considered, at a point inside an elastic spherical layer, surrounding an elastic homogeneous sphere of different properties; the motion at a point of the surface, due to the Love waves, is calculated and compared to the motion at the surface of a plane layer, covering an elastic half-space. Owing to the curvature of the surface, the long-period waves are more dispersed, and the

beginning of the train of waves is stretched forward; the first long-period waves arrive with a velocity greater than that of the '*SH*' waves in the underlying medium, and the amplitude of the subsequent motion grows more slowly with time. A.

550.38

5125. The geomagnetic post-perturbation effect. R. P. W. Lewis. *J. atmos. terrest. Phys.*, **6**, *No.* 2–3, 129–32 (*March*, 1955).

The belief that during magnetically quiet periods following disturbance the horizontal force H continues to increase for a very long time is shown to be ill-founded. A tentative estimate is made of the actual duration of the recovery of H to its undisturbed level. A.

550.384

5126. The qualitative explanation of the onset of certain polar magnetic perturbations by means of the theory of Chapman and Ferraro. G. Grenet. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 4, 448–50 (*Jan*, 24, 1955) In French.

The observed values of the rate of increase of H, and of its total initial increase, in certain polar magnetic perturbations lead to estimates of the rate of approach of the supposed ionized stream from the sun, and of the distance from the earth at which it is arrested. These estimates are both in excess of those required for the Chapman–Ferraro theory. It is concluded that this theory provides a qualitative but not a quantitative explanation of these phenomena.

A. T. PRICE

550.385 : 551.594.5

5127. Note on the occurrence of world-wide s.s.c.'s during the onset of negative bays at College, Alaska. J. P. Heppner. *J. geophys. Res.*, **60**, *No.* 1, 29–32 (*March*, 1955).

World-wide sudden commencements which appear during the night hours at College, Alaska, are found to occur most frequently during the onset, or decreasing H stage, of negative bays. As this stage of magnetic disturbance accompanies a distinct change from homogeneous to rayed aurora, it is suggested that s.s.c.'s have an atmospheric source which is related to sudden changes in auroral activity. A.

550.386

5128. Solar corpuscles responsible for geomagnetic disturbances. J.-C. Pecker and W. O. Roberts. *J. geophys. Res.*, **60**, *No.* 1, 33–44 (*March*, 1955).

A qualitative hypothesis is given that attributes recurrent "*M*-region" geomagnetic disturbances to the arrival at the earth of solar corpuscles that have been gathered into beams by the deflecting action of coronal-region fields, presumably magnetic, associated with centres of heightened solar activity. The hypothesis identifies the source of solar corpuscles that produces *M*-region magnetic disturbances with "quiet areas" of the solar surface. A related hypothesis associates non-recurrent magnetic storms, the greatest ones, with a different solar corpuscular source, found in the active region itself. A.

550.93 : 539.16.08

5129. Proportional counting of carbon dioxide for radiocarbon dating. H. R. Brannon, M. S. Taggart, Jr and M. Williams. *Rev. sci. Instrum.*, **26**, *No.* 3, 269–73 (*March*, 1955).

Determinations of naturally occurring radiocarbon have been made with proportional counters filled with carbon dioxide at pressures up to 10 atm. After chemical and radiochemical purification, the sample is converted into carbon dioxide for the counter filling. Extreme purity is required of the counter filling gas to prevent electron attachment by impurities. Procedures are described for producing carbon dioxide of sufficient purity to provide consistent and reproducible results. A counting efficiency of 100% is obtained for carbon-14 β's contained in the active volume of the counter, giving a sample counting rate for the counter used for 45 c.p.m. for contemporary material at a filling gas pressure of 10 atm. With the present background of 13·5 c.p.m. and a counting time limit of two days, dating may be extended to a maximum age limit of 42 000 years. A.

ATMOSPHERE . METEOROLOGY 551.5

551.510.41

5130. Variations in the total amount of ozone over Tromsø, and their correlations with other meteorological elements. H. Johansen. *Geofys. Publ.*, **19**, *No.* 5, 18 *pp.* (1955).

Based on simultaneous observations of upper air and ozone over Tromsø during the period May, 1941–October, 1944, a mainly statistical analysis has been made to establish the connections between the total amount of ozone and other meteorological elements. Correlation coefficients with upper air pressure and temperature show small values in midwinter but a maximum April–May. For pressure and temperature the maximum correlation between 3 and 15 km, occurs at 6 km, while for potential temperature in the stratosphere the maximum is at 12–14 km and decreases upwards to 18 km. The annual variation of correlation coefficients and of the O_3 gradient at 60–70°N shows that the variation is not due solely to horizontal advection. The importance of dynamical processes to the connection between O_3 and weather is shown by the variation of total O_3 being related to (1) the fall and rise region of atmospheric pressure at ground level, (2) height of the tropopause, (3) upper pressure variations. The O_3 content varied inversely to the upper cold troughs and warm ridges and was a maximum in spring and autumn. A close connection existed between O_3 variation and upper convergence and divergence.

R. S. REED

551.510.534

5131. Vertical distribution of atmospheric ozone at Longyearbyen, Spitzbergen (78°N). S. H. H. Larsen. *J. atmos. terrest. Phys.*, **6**, *No.* 1, 46–9 (*Jan.*, 1955).

Results are presented and compared with the Tromsø distribution (70°N). A.

551.510.534

5132. The vertical distribution of atmospheric ozone from balloon ascents. H.-K. Paetzold. *Z. Naturforsch.*, **10a**, *No.* 1, 33–41 (*Jan.*, 1955) In German.

An ultraviolet spectrograph has been used for

balloon ascents at Weissenau. The observed variations show that there must be vertical motion with a velocity of greater than 1 cm/sec for heights between 20 and 45 km; at 20 km the atmospheric ozone concentration drops sharply. In the spring there is a secondary maximum at 15 km due to the arrival of polar air. The mean curves show a seasonal variation to lower heights in the spring and a mean velocity of change of 0·1 mm/sec. The other variations in the curves can be explained in terms of turbulence, photochemistry, etc. J. M. HOUGH

551.510.535

Radio-wave propagation in the ionosphere. *See also under* "Electromagnetic waves and oscillations." Decimal classification 538.566.3

551.510.535

5133. A peculiarity of the *F*2-layer at Lwiro. G. BONNET. *Ann. Géophys.*, **10**, *No.* 4, 348–50 (1954) In French.

An analysis of very rapid variations of heights of the *F*2 night-time peak during equinoctial periods is given. An increase of the peak altitudes is very often related to the presence of a layer corresponding to a night-time *E*-layer. A.

551.510.535

5134. Variation of the angle of arrival of the down-coming radio waves from the ionosphere with the appearance of scattered signals. S. S. BANERJEE AND D. K. BANERJEE. Letter in *J. sci. industr. Res.*, **13B**, *No.* 12, 881–2 (*Dec.*, 1954).

The angle of arrival of the down-coming radio waves from the *F*2-region on 31 m transmitted from Delhi and received at Banaras was determined from the phase difference in the e.m.f.'s induced in two vertical dipoles. Typical c.r.o. patterns before and after the appearance of scattered signals in the afternoon hours are illustrated and results given for the distances and location of the scattering centres. G. M. BROWN

551.510.535

5135. Widespread diurnal variations of effective slope of the ionosphere. H. A. WHALE. Letter in *Nature* [*London*] **175**, 77–8 (*Jan.* 8, 1955).

Measurements made over a year at Auckland on a rotating interferometer of the bearing and elevation angles of radio signals received from 2 transmitting stations allow the average diurnal variation of effective slope of the ionosphere to be found. The stations operate on 9·32 and 9·66 Mc/s and each is situated at about 2000 km from the receiving station but in directions almost magnetically north and west respectively. Only the horizontally polarized incoming component is received. G. M. BROWN

551.510.535

5136. On the conditions of vertical reflection in the ionosphere in the presence of collisions and of the terrestrial magnetic field. Case of the *E*-layer. D. LEPECHINSKY AND J. DURAND. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 3, 333–6 (*Jan.* 17, 1955) In French.

It is claimed that the usual vertical incidence reflection condition ("quasi-transverse," Q.T.) is only valid for the *E*-layer for regions of the earth where the inclination of the terrestrial magnetic field $\theta < 65°$. For $\theta > 65°$ the propagation is "quasi-longitudinal" (Q.L.) and the reflection condition has to be substantially altered. The noon flattening of the diurnal f_0E-curves for Poitiers is eliminated if it is assumed that around noon the layer falls in altitude to a region of increased collisional frequency which changes the propagation from Q.T. to Q.L. G. M. BROWN

551.510.535

5137. On a lunar influence on the ionization maximum of the ionospheric *E*-layer. E. HARNISCHMACHER. *C.R. Acad. Sci.* [*Paris*] **240**, *No.* 5, 553–5 (*Jan.* 31, 1955) In French.

The sub-solar critical frequency of the *E*-layer has been determined graphically from monthly median diurnal values of f_0E for a variety of stations. Allowing for the equation of time this shows a small seasonal influence, a larger effect of colatitude and solar cycle and a further variation of amplitude 1% which is a function of lunar phase. A similar influence, also centred on full moon, exists for the "electron dissipation index" *n*. G. M. BROWN

551.510.535

5138. Sporadic *E* movements. N. C. GERSON. *J. Meteorol.*, **12**, *No.* 1, 74–80 (*Feb.*, 1955).

Sporadic *E* trajectories determined over the United States seem to indicate atmospheric movements at 110 km which are predominantly from the east during summer. Speeds were found to average about 300 km/hr. The motions observed were mainly translational, although on some occasions strong vortical movements were revealed. A summary of winds to 120 km, determined by a variety of techniques, indicates the winds at all altitudes are predominantly from the west during winter and from the east during summer. A.

551.510.535

5139. Absence of bifurcation in the *E*-layer. J. C. SEDDON AND J. E. JACKSON. Letter in *Phys. Rev.*, **97**, *No.* 4, 1182–3 (*Feb.* 15, 1955).

Electron density distribution curves are given covering the altitude range 90–150 km as obtained from three separate New Mexico rocket flights spaced over 5 years. Reasons are given for placing considerable confidence in the results. All fail to show any bifurcation in the day-time *E*-layer, in contradiction of the results of Lien, Marcou *et al.* [Abstr. 2945 (1954)]. See also following abstract. G. M. BROWN

551.510.535

5140. Further remarks on the bifurcation in the *E*-layer. W. PFISTER, J. C. ULWICK AND R. J. MARCOU. Letter in *Phys. Rev.*, **97**, *No.* 4, 1183–4 (*Feb.* 15, 1955).

Reply to Seddon and Jackson (preceding abstract), pointing out that the results of both groups of workers are consistent within themselves but depend on different analyses—Seddon's experiments are based on the change in phase delay, while the authors' give the group delay. It is pointed out that the magnetic field has an important effect on the ray paths and adequate allowance for this may affect the results of both experiments. G. M. BROWN

551.510.535

5141. Movement of the *F*-region. K. TOMAN. *J. geophys. Res.*, **60**, *No.* 1, 57–70 (*March*, 1955).

In the course of a fixed-frequency ionospheric study, employing a pulse-triggered transmitter operating on 3·5 Mc/s and three spaced-receivers, the transmission delay was continuously recorded. Aside from a vertical-incidence transmission, two oblique transmissions were thus available with 62 and 109 km as base lines, the latter being correspondingly oriented in an approximate west-east and northwest-southeast direction. An analysis of the echoes from the *F*-region was made for the period between August, 1952, and December, 1953. Successive irregularities observed simultaneously on three records displayed frequently consistent time-displacements. Assuming the mid-points of the transmissions to be characteristic and preferred areas for the reflection of the h.f.-pulses, the time-displacements were interpreted as being due to a mechanical motion of the *F*-region. Direction and speed of this movement were thus obtained, and semiannual and annual periods of these components became apparent. A.

551.513

5142. Atmospheric turbulence and diffusion. II. K. R. SAHA. *Indian J. Meteorol. Geophys.*, **5**, *No.* 4, 297–304 (*Oct.*, 1954).

For Pt I, see Abstr. 4233 (1955). Includes (1) recent developments in theories of turbulence: study of isotropic turbulence, (2) Kolmogoroff's similarity hypotheses, with experimental tests and application to the atmosphere, (3) Weizsäcker–Heisenberg theory of turbulent energy transfer. It is concluded that knowledge of the scales of turbulence intermediate between the big vortex and the small size where similarity ideas apply is still required.

R. S. READ

551.521

5143. The global radiation in a Rayleigh atmosphere. D. DEIRMENDJIAN AND Z. SEKERA. *Nature* [*London*] **175**, 459–61 (*March* 12, 1955).

A brief account of the application of Chandrasekhar's treatment of radiative transfer to global radiation which permits the sky radiation to be separated from the direct solar radiation. Results are given in graphical form and allowance is made for the planetary reflection of the earth on the assumption of Lambert's law. J. M. HOUGH

551.521.13

5144. The solar constant. F. S. JOHNSON. *J. Meteorol.*, **11**, *No.* 6, 431–9 (*Dec.*, 1954).

The value of the solar constant indicated by 30 years of observation by the Smithsonian Institution is revised in the light of the scale correction announced in 1952 and new solar spectral-irradiance data for outside the earth's atmosphere obtained by the Naval Research Laboratory. The ultraviolet and infrared corrections applied by the Smithsonian Institution in solar-constant determinations are examined and re-evaluated. The accuracy of their measurement of total irradiance in the spectral range 0·346 to 2·4μ is in general supported, only a 0·3% increase being indicated owing to revision of a correction applied in reaching their value. The corrections for radiation outside this spectral range are found to be larger than those used by the Smithsonian Institution. The new value of the solar constant is 2·00 calories per $cm^2.min^{-1}$, with a probable error of 2%, and the solar-illuminance constant is 13·67 lumen per cm^2 (12 700 foot-candles). A.

551.543 : 551.509

5145. Dynamic surface-pressure changes and their significance for weather forecasting. S. BRANDEJS, J. KOPÁČEK, V. VÍTEK and O. ZIKMUNDA. *Czech. J. Phys.*, **4**, *No.* 3, 350–70 (*Sept.*, 1954).

An equation is derived for dynamic surface-pressure changes. The development term of this equation is applied to certain synoptic situations and its diagnostic and prognostic value is studied. A.

551.593.9

5146. Photoelectric studies of the night sky light. M. HURUHATA. *Ann. Tokyo Astron. Obs. Univ. Tokyo* (*Second Ser.*) **3**, *No.* 4, 165–74 (1953).

Photoelectric photometries of the main five emissions made from November, 1946, to July, 1948, were discussed in their daily, seasonal and yearly intensity variations, besides the heights of their emitting layers. The variations were compared with the available ionospheric data. The mean correlations of the intensities of the emissions in twenty nights with the electron density of the *F*2-layer are positive for all lines. The method of reducing the height of emitting layer of the night-sky light was examined, by considering (1) computing formulae, (2) effect of extinction, (3) drift of the night-sky light; and 300 km is concluded as the most reliable value of the height. A.

551.593.9

5147. A comprehensive study of atomic emissions in the nightglow. H. B. PETTIT, F. E. ROACH, P. ST. AMAND AND D. R. WILLIAMS. *Ann. Géophys.*, **10**, *No.* 4, 326–47 (1954).

A study of the nightglow emissions at λ5 577, λ5 893 and λ6 300 Å at Cactus Peak, California during the period November, 1948, to March, 1954, shows that the diurnal and seasonal intensity variations are in good agreement with previous reports. No correlation between sunspot activity and the intensity of any of the emissions is found. The only positive correlation between any two of the emission intensities is for 5 893 and 6 300. The directional tendency for the area of maximum brightness for any one night to be north, in the zenith, or south of Cactus Peak has a seasonal variation in all three emissions, that of sodium being the most pronounced. In the summer, when the intensity for sodium is the lowest, the predominant direction of its maximum is south; in the winter, when the intensity is greatest, the direction is north. This fact leads to a prediction of a possible geographical motion of the maximum intensity area of sodium. A.

551.593.9

5148. The effect of resonance absorption on the determination of the height of airglow layers. T. M. DONAHUE AND A. FODERARO. *J. geophys. Res.*, **60**, *No.* 1, 75–86 (*March*, 1955).

The theory of the self-absorption of resonance photons within a luminescent airglow layer is developed and expressions obtained analogous to the Van Rhijn equation for the variation of intensity as

a function of zenith angle. The measured flux is shown to be a function of $L_0/\sqrt{T}$, where L_0 is the vertical thickness in atoms/cm^2 and T the absolute temperature of the layer. The attenuation at large zenith angles in the case of the sodium D-lines is shown to be large enough when L_0 is between 1 and 2×10^{10} cm^{-2} and T between 160 and 220° to cause a layer at 70 km to simulate a non-absorbing (Van Rhijn) layer between 200 and 300 km. If self-absorption is important, it is shown that the ratio of D_1 to D_2 intensity should vary with zenith angle and different apparent heights found for the two components. Accurate measurements of L_0 and T are shown to be necessary for even good approximate height deductions where resonance radiation (for example, Na and OI) is concerned. A.

551.593.9

5149. The OH bands in the infrared airglow. J. W. CHAMBERLAIN AND F. L. ROESLER. *Astrophys. J.*, **121**, *No.* 2, 541–7 (*March*, 1955).

A series of infrared airglow spectra have been made at 70 Å/mm, in order to obtain accurate wavelengths of the high-excitation ($v' = 8$ and 9) Meinel OH bands. Band origins have been measured with a very small probable error, and the agreement between the airglow 6–2 and 5–1 bands with earlier high-dispersion measurements in the laboratory indicates that there are no appreciable systematic errors such as plagued previous measurements. In order to represent accurately all energy levels up to $v = 9$, it is necessary to use five terms in the usual power series involving ω_e, $\omega_e x_e$, etc. These vibrational levels are discussed, and a possible blending of airglow lines with [O II] in the infrared auroral spectrum is pointed out. A.

551.593.9

5150. Collisional deactivation and the night airglow. D. R. BATES. Note in *J. atmos. terrest. Phys.*, **6**, *No.* 2–3, 171–2 (*March*, 1955).

Since near the 100 km level the mean number of O_2 molecules dissociated by photoreaction is $\sim10^{12}$ molecules/cm^2 column. sec, predicted intensities in the $\alpha^1\Delta g$, $b^1\Sigma_g^+$, $^1\Sigma_u^-$, $^3\Delta_u$ and $A^3\Sigma_u^+$ excited states should be $\sim10^{10}$—10^{11} photons/cm^2 column. sec. However, few of these bands have been detected in the spectrum of the night airglow. To account for this fact, it is proposed that deactivation may occur as the result of indirect conversion of electronic to kinetic energy through atom-atom interchange. For example, in the conversion of an O_2 molecule in a state, α, to one in a lower state, β, involving a free O atom, the process will be $O(^3P) + O_2(\alpha) \rightarrow O_2(\beta) + O(^3P)$. D. R. BARBER

551.594.12

5151. On the contribution of alpha rays from the ground to the total ionization of the lower atmosphere. V. F. HESS AND W. D. PARKINSON. *Trans Amer. Geophys. Un.*, **35**, *No.* 6, *Pt* 1, 869–71 (*Dec.*, 1954).

Alpha-ray ionization is perhaps the most variable single component of the ionization of the lower atmosphere. Many measurements have been made to determine the ionization from airborne sources of α-rays. This depends principally on the amount of radon and thoron in the atmosphere. An attempt is made here to evaluate the rôle of α-rays originating from the surface of the ground and other naturally occurring surfaces. It was found that about 10% of the small ions observed at one metre above ground are originally produced at the ground and carried upward by convection. A.

551.594.12

5152. Electric charges measured in the air when blowing snow. H. NORINDER AND R. SIKSNA. *Ark. Geofys.*, **2**, *Paper* 14, 343–69 (1955).

An experimental investigation of the ions produced in air when snow is blown through it. Small ions were detected with a Weger condenser and large ions with an Israel counter. The small ions were divided into three components, invisible snow particles, atmospheric small ions and particles with mobilities intermediate between those of atmospheric small and large ions. Only part of the large ions were due to atmospheric large ions, the other part consisted of particles carrying a larger charge. No attempt is made to fit these results into a theory. J. M. HOUGH

551.594.13

5153. Effects of radioactive debris from nuclear explosions on the electrical conductivity of the lower atmosphere. D. L. HARRIS. *J. geophys. Res.*, **60**, *No.* 1, 45–52 (*March*, 1955).

An increase in the ionization near the ground due to the fall-out from a radioactive cloud formed by a nuclear explosion will increase the conductivity and lower the potential gradient in the lower atmosphere. Records of atmospheric conductivity and potential gradient from the Tucson Magnetic Observatory are compared with records of the deposition of atomic debris on the ground following the Nevada tests. The observed changes are not inconsistent with values computed from theoretical considerations. Most of the effects are confined to a very shallow layer, within a few metres of the ground. A.

551.594.21

5154. The distribution and discharge of thunderstorm charge-centers. S. E. REYNOLDS AND H. W. NEILL. *J. Meteorol.*, **12**, *No.* 1, 1–12 (*Feb.*, 1955).

The magnitude and location of the charge centres involved in lightning discharges can be determined from the value of the accompanying gradient change at seven points at the ground. Instrumentation, calibration, observation and analysis techniques for thus locating thunderstorm charge-centres are described. The results of the analysis are presented. The thunderstorm is found to be bipolar, with the negative centre at a mean height of 25 000 ft or −16°c, and with the positive centre located about 2 000 ft above it. The occasional occurrence of a positive centre below the negative centre is shown by the record of the leader processes of ground discharges and from other evidence. Comparison is made with the work of Malan and Schonland in South Africa. While the results are in substantial agreement, important differences in the nature of streamer processes and the relative location of the negative centres tapped by successive elements of a single ground discharge are noted. The cold environment found for many of the negative charge centres (as low as −33°c) strongly suggests that these centres might not have been produced by a glaze-ice mechanism. Riming and,

perhaps, sublimation are probably the important processes for precipitation growth at such low temperatures. A.

551.594.25

5155. The systematic electrification of mist and light rain in the lower atmosphere. R. GUNN. *J. geophys. Res.*, **60**, *No.* 1, 23–7 (*March*, 1955).

The rôle of ionic diffusion in placing free electrical charge on droplets falling in the atmosphere is considered. Experimentally verified expressions for the diffusion of ions on to droplets are shown to account for the sign and magnitude of the free charge observed on light rain and mist. In the lower atmosphere, such droplets are normally positive and carry a specific free charge approximating 1 e.s.u./g. The observed variability of the electrical conductivity of the atmosphere suggests that diffusion may occasionally transfer large negative as well as positive charges to the falling drops. A.

551.594.6

5156. An attempt to observe whistling atmospherics near the magnetic equator. J. R. KOSTER AND L. R. O. STOREY. Letter in *Nature* [*London*] **175**, 36–7 (*Jan.* 1, 1955).

No whistling atmospherics have been observed at Achimota, Gold Coast (geomagnetic latitude 10°N) over a three-year period when other observations indicated that they were common in middle latitudes. This is in agreement with the Barkhausen–Eckersley theory of the production of whistlers. G. M. BROWN

BIOLOGY 57/59

MEDICAL SCIENCE . HUMAN PHYSIOLOGY 61

612.843.2

5157. On the summation of differential stimuli by the recruitment of retinal elements. A. KÜHL. *Optik*, **12**, *No.* 2, 94–8 (1955) In German.

An extension of Berek's theory [*Zeitschrift für Instrumentenkunde*, **63**, 297 (1943)] to cover Yunta's work [*Coloquio sobre Problemas Opticas de la Vision, Madrid* (1953)]. R. A. WEALE

612.858

5158. On latent damage to the ear. J. D. HARRIS. Letter in *J. Acoust. Soc. Amer.*, **27**, *No.* 1, 177–9 (*Jan.*, 1955).

The purpose of this communication is to serve as a warning to the now numerous people seeking to prevent partial deafness in ears subjected to loud noise. If the results in the figures herewith can be extended to the case of permanent threshold shifts, they may indicate that work periods should be set not only to allow the ear to recover to normal by audiometric test, but to provide in addition a time interval sufficient for the effects of latent damage to be dissipated. A.

TECHNIQUE. MATERIALS 62/69

PHOTOGRAPHY 77

772

5159. Formation of photographic positives on strained single crystals of silver chloride. H. LEIDHEISER, JR AND F. H. COOK. Letter in *J. chem. Phys.*, **23**, *No.* 3, 595–6 (*March*, 1955).

The crystals were etched by diluted acid fixer after being machined to spherical shape. Exposure and development then gave positive images, and these could be repeated several times after etching. When finally the etch pattern became undistorted, negative images resulted. Positive images could be produced by machining again, negative ones by annealing above 380°C. It is supposed that the strain of machining produces a deep internal latent image which is only revealed (as a negative) when the crystal has been etched down to this level. S. T. HENDERSON

778.34

5160. Microinterferometric examination of nuclear emulsion plates. B. S. THORNTON. Note in *Austral. J. Phys.*, **7**, *No.* 4, 652–4 (*Dec.*, 1954).

Tracks produced at grazing incidence have been examined by an interference microscope in reflection. Slight differences were noted between proton and α-particle tracks. The technique and the problem of examining tracks by an interference system in transmission are discussed. D. J. PROWSE

778.34 : 537.534.74

Measurement of the scattering constant in nuclear emulsions. *See Abstr.* 4740

778.34 : 539.18

On the determination of the mass of unstable heavy particles by photometry of their tracks in nuclear emulsions. *See Abstr.* 4977